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MISSOURI RIVER

SIOUX CITY, IOWA TO RULO, NEBRASKA.

POTAMOLOGY INVESTIGATION.

RELATIONSHIP BETWEEN CALCULATED HYDRAULIC PARAMETERS AND PHYSICAL FEATURES OF THE CHANNEL

PREPARED BY
WATER AND ENVIRONMENT CONSULTANTS, INC.
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CORPS OF ENGINEERS
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SYLLABUS

The data gathered in the 1971 Hydrographic Survey of the Missouri River by the U.S. Army Corps of Engineers, Omaha District, were studied to determine the relationships between the physical features (i.e., area, control structures, and bend geometry) to the hydraulic parameters (i.e., average velocity, shear velocity, and resistance to flow). Recommendations concerning data collection are presented.

The results of the analysis show that resistance to flow is directly proportional to flow area and the hydraulic radius, whereas it is indirectly proportional to the velocity. The effects of the bend geometry (radius of curvature, length of bend, and central angle of bend) on the resistance to flow seem to be masked out by effects of the major sand bars, by training works constructed along the reaches, and by changes in the bed roughness. A steady increase in the size of bed material is present for the whole reach studied, indicating possible changes in the resistance to flow. Also, potential points or problem areas in terms of navigation depth and local aggradation can be found through inspection of the six plates prepared from the data.

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Letter on file

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PURPOSE

The purpose of this investigation is to:

(1) Evaluate and relate the hydraulic parameters of the Missouri River from Sioux City, Iowa to Rulo, Nebraska to the physical features of the channel such as channel width, control structures, and bend geometry; and

(2) Offer recommendations regarding further data collection and computational programs.

The data supplied for analysis includes:

(1) Tabulation of Calculated Hydraulic Parameters,

(2) 1971 Hydrographic Survey, and

(3) Water Temperature Data.

DESCRIPTION

This study utilizes the basic data provided by the Omaha District of the Corps of Engineers. The basic data include a tabulation of calculated hydraulic parameters which is displayed in the appendix, and the maps and data of the 1971 hydrographic survey of the Missouri River.

To more clearly ascertain the actual effects of the physical features of the channel (control structures, width, area, and bend geometry) on the hydraulic parameters involved with the channel flow (average velocity, shear velocity, resistance to flow, etc.), a comprehensive set of figures were made whereby selected basic data and computed parameters were plotted as a function of river mile from Sioux City, Iowa to Rulo, Nebraska. These figures clearly illustrate the interaction between the alignment of the channel, the water surface slope, characteristics of the bed material, top width of the channel, the cross sectional area of the flow in the channel, the hydraulic radius of the channel, the average velocity in the channel, the shear velocity in the channel, and the resistance to flow in the system as denoted by Manning's resistance coefficient (Plates 1-6). Each parameter on the plates has its own vertical scale whereas the horizontal scale is marked every five miles and is the same for all parameters. Each point on the figures corresponds to the average value of the respective parameter for the river reach beginning at the river mile represented by that point and ending at the mile represented by the next point downstream. Thus each point indicates the beginning of the bend or crossing and represents the value of that parameter for that reach which ends at the location of the next point.

In addition to the view of the trends and effects offered by the plates, four figures were prepared to show the effect of bend area, central angle, length, and radius of curvature on flow resistance. All bends in the study length were measured for θ, L_b, and R_c, and those values along with the area of the bends were plotted against flow resistance as shown in figures 1-4.

RESULTS OF THE INVESTIGATION

The data utilized in this report were collected for the whole system over a sufficiently short period of time so that the discharge remained essentially constant (from 48,000 to 52,000 cfs). This condition allows an excellent opportunity to study the variation in the hydraulic parameters over a relatively long reach of river.

Referring to Plates 1-6, many interesting and important points pertinent to the understanding of the river mechanics of the system are found. Study of the plates indicates that where the area of the water cross section is small, the hydraulic radius and resistance to flow are correspondingly small, whereas the velocity is correspondingly large. In this regard, Plates 1-6 give considerable positive and useful evidence showing how the hydraulics of the system relate to the geometry of the system. Additional positive points resulting from analysis of Plates 1-6, as well as identification of problem areas and work that should be done as a follow-up, will be identified in the conclusions.

Although Plates 1-6 give considerable evidence of the interaction of the geometric and hydraulic properties of the system, some limitations of comparison appear as one tries to determine the relationships between resistance to flow and the geometry of bends. Figures 1,2, and 3 have been prepared to show the relationship of resistance to flow as represented by u/u_* to radius of curvature, central angle, and length of bends. The only conclusion to be made from Figures 1,2, and 3 is that there is no close correlation between the resistance to flow and the radius of curvature, central angle, and length of bends in this system. There appears to be a greater variation in resistance to flow due to changes in the hydraulic parameters such as area and slope. Figure 4 shows the close correlation between area and resistance to flow.

In attempting to relate the control structures to hydraulic parameters, specifically to structure density and the form resistance, a scattering of

points indicated that the data provided no positive relationship. Structure density is a vague term which is hard to uniformly quantify, since varying types of control structures exist along the length of the river and their influence is difficult to single out. Also, other factors of form resistance such as bed forms and bar formations exert an influence on form resistance. Because of the interaction of many variables on the form resistance and the fact that structure density is hard to quantify, a relationship between control structures and form resistance is not evident in the data.

CONCLUSIONS

The data compiled for the Missouri River offers a comprehensive look at the mechanics of flow in the reach covered by the data. Such comprehensive data over a long reach of river for essentially constant discharge gives an excellent opportunity to determine how such critical variables as resistance to flow, shear velocity, average velocity, hydraulic radius, area, top width, and grain size vary in such a system. More specifically, (1) by referring to Plates 1-6 it is obvious that where the cross sectional area of the water is relatively small, the resistance to flow is relatively small, the hydraulic radius is relatively small, and the average velocity is relatively larger. Conversely, where the cross sectional area of the water is larger, the forms of bed roughness have increased the resistance to flow and the average velocity is consequently smaller.

(2) Studying the effects of radius of curvature, length, and internal angle of each bend, it is difficult to find any correlation between these variables and the resistance to flow. With the data available to us it is our conclusion that such geometric factors as length, internal angle, and radius of curvature of bends do have an effect on resistance to flow, but in this instance their effects are masked by changes in the bed roughness, by the effect of major sand bars, and by revetment and training works constructed along the reaches. It is possible that additional analysis could determine which parameters are most sensitive under various flow conditions and at what point bend geometry could become an important influence of flow resistance.

(3) An interesting observation of the characteristics of the bed material is that both the D65 and D35 sizes of the bed material increase with river distance throughout the reach from Sioux City to Rulo. The increase in size of bed material is approximately 25 percent for the reach. This is an extremely interesting phenomenon and with additional study should

be related to changes in resistance to flow, sediment transport, the form of bed roughness, and velocities in the system.

(4) Studying Plates 1-6 enables one to compare key variables with the planned geometry of the system, and it is easily ascertained where potential problem areas may exist in terms of navigation depth, local aggradation, and so forth. Inspection of the plates shows specific bends and crossings which have abrupt changes in the average values of parameters such as area, flow resistance, velocity, and hydraulic radius which reflect on the ability of that reach to transport sediment and maintain desired cross-sectional characteristics. For example, reaches with larger areas and lower velocities have lower transport capabilities which may indicate possible aggradation areas accompanied by a less stable cross-section and possible navigation problems. Areas vulnerable to additional degradation may be found where relatively higher velocities exist along reaches with smaller relative cross sectional areas.

(5) It should be stressed that with the data available and some additional sediment transport analysis, it is possible to compute the sediment transport for each sub-reach throughout the total system. Having done these computations one could quite adequately determine source and sink areas of sediment along the whole system, which should correlate extremely well with navigation problems, channel changes, and need for dredging.

Based upon the analysis of this report, it is desirable to make certain recommendations concerning additional computational programs and additional data or hydraulic parameter analyses which would possibly aid in further evaluation.

It would be extremely worthwhile to expand the data collected for this study to include similar data measured at other discharges and temperatures of flow. This additional information would provide better insight to the variation of resistance to flow with stage or discharge and also help evaluate

the effects of temperature on resistance to flow, stage, and bed forms in the river system.

Sediment transport in the system was not a part of the study. However, sediment transport is an essential and important part of the river system that should be considered in future study. In this regard, it would be extremely worthwhile to study the transport capability of the river system, reach by reach, and put this together so that one has an understanding of the transport of the total system. Possibly by putting computed bed material transport on Plates 1-6, additional insight to the problem could be obtained. This would become even more valuable should data similar to that provided for this report be collected at different discharges. If such data were taken, it would give extremely important information on the variability of transport throughout the system for differint discharges. This could be useful from the viewpoint of planning future channel changes and studying navigation problems in greater detail.

Another function related to the transport capacity of the river is ψ. Study of this function should reveal potential aggradation and degradation problems and also give some insight to bed configuration and resistance to flow.

APPENDIX

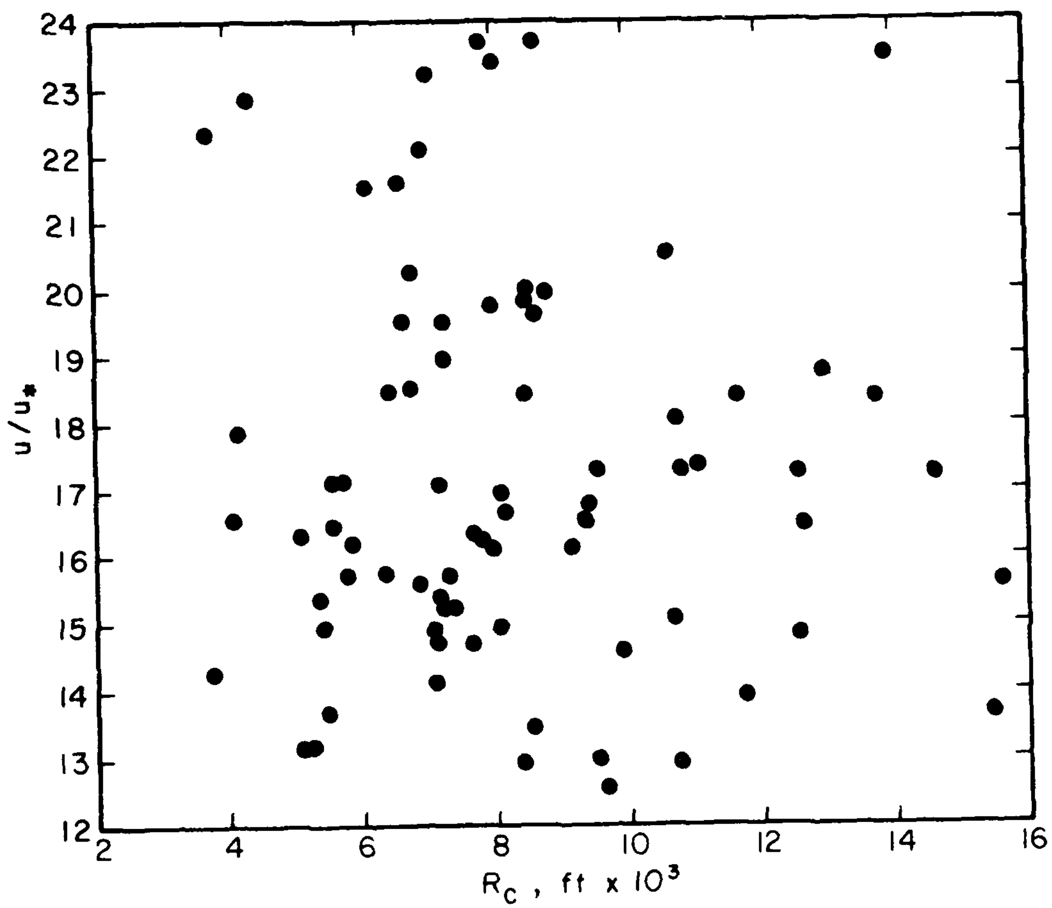


FIGURE 1. RELATIONSHIP BETWEEN RADIUS OF CURVATURE AND FLOW RESISTANCE

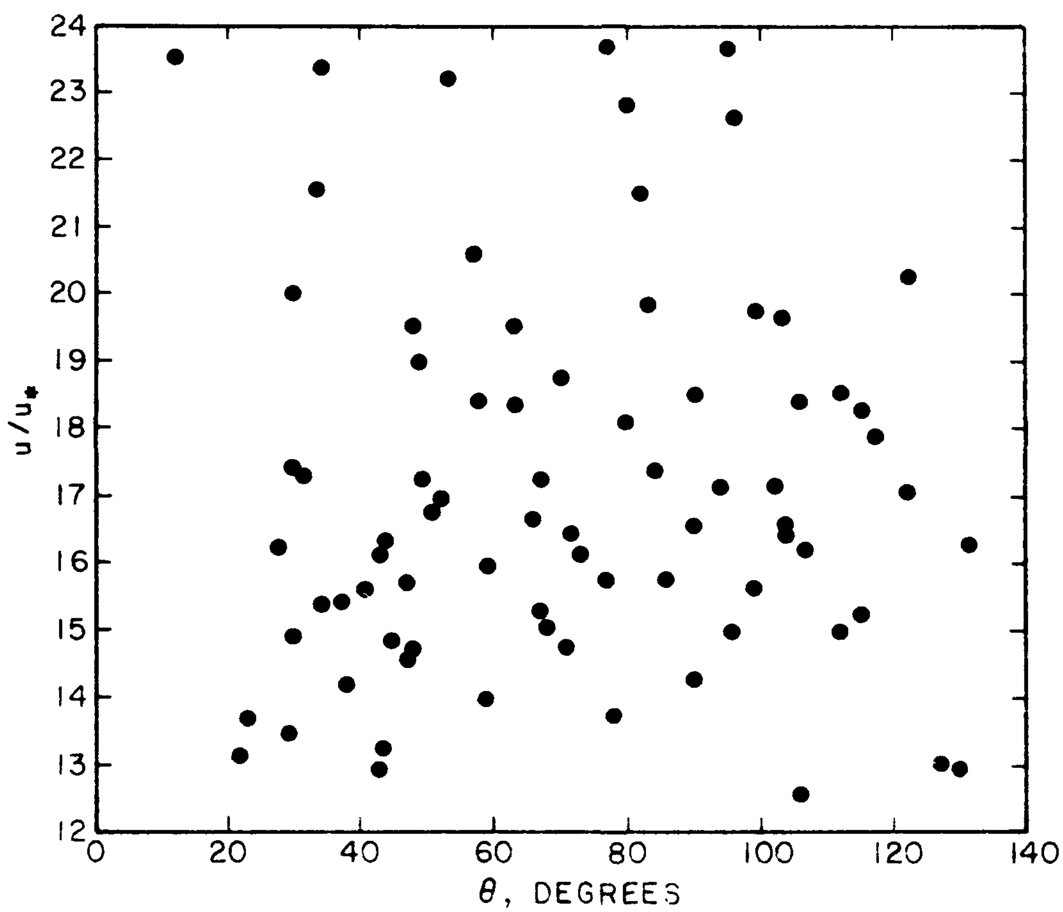


FIGURE 2. RELATIONSHIP BETWEEN CENTRAL ANGLE AND FLOW RESISTANCE

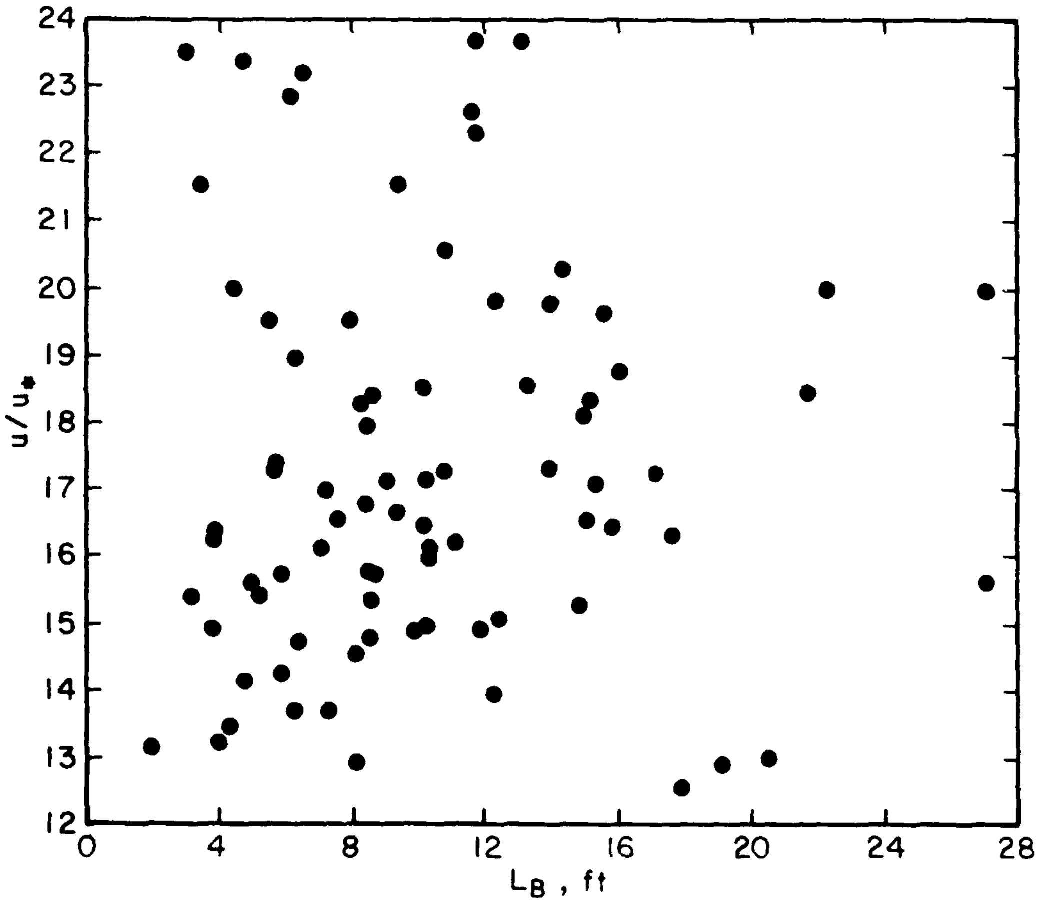


FIGURE 3. RELATIONSHIP BETWEEN LENGTH OF BEND AND FLOW RESISTANCE

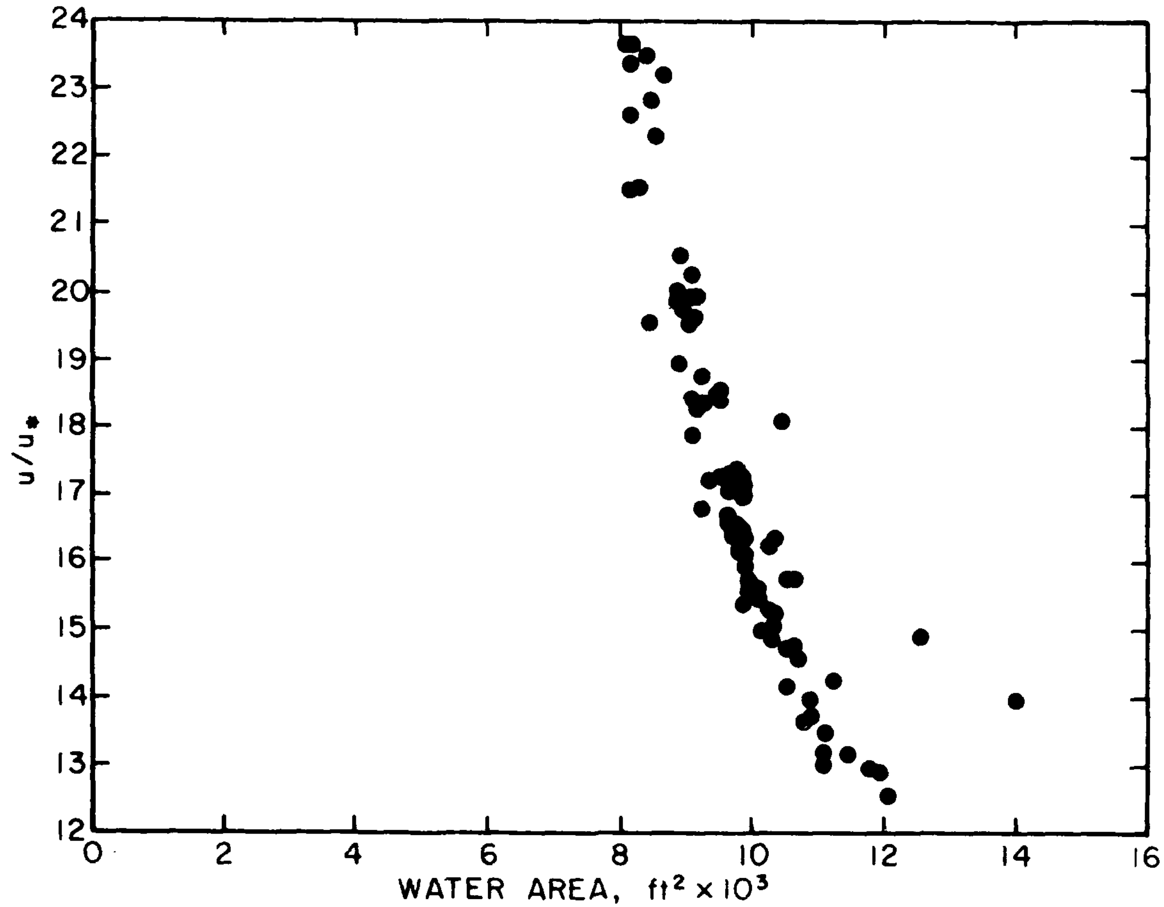


FIGURE 4. RELATIONSHIP OF WATER AREA AND FLOW RESISTANCE

1971 MISSOURI RIVER [illegible] FROM SIOUX CITY TO [illegible]

	RIVER MILE U/S	RIVER MILE D/S	SLOPE FT/FT	Q CFS	N	TW FT	AREA SQFT	H FT	AR2/3	K	VEL F/S	MEAN THAL FT	MEAN THAL MSL	PC DEP BELOW MEAN
	753.74	753.33	0.000189	48000	0.0276	1407	13973	9.95	64720	3487553	3.43	27.44	1076.54	45.41
x	753.30	752.86	0.000194	48500	0.0295	1332	14167	10.64	68516	3448882	3.39	20.51	1083.45	46.42
	752.85	752.15	0.000187	48000	0.0252	1159	12544	10.82	61370	3427953	3.53	20.49	1082.91	41.34
x	752.15	751.56	0.000193	48000	0.0376	940	13101	13.94	75871	3458666	3.66	22.61	1079.55	34.23
	751.56	750.33	0.000195	48100	0.0321	750	11767	15.69	73741	3417809	4.09	26.71	1074.38	46.46
x	750.03	749.28	0.000197	48100	0.0244	1092	11646	10.66	58411	3428960	4.13	21.39	1077.05	52.93
	749.25	748.94	0.000211	48100	0.0294	733	10877	14.83	69452	3314806	4.41	22.92	1075.88	56.69
x	748.94	746.21	0.000215	48200	0.0350	733	11925	16.35	77287	3304429	4.02	21.45	1075.53	57.14
	746.21	742.59	0.000210	48300	0.0317	620	11945	14.55	71215	3314619	4.04	23.70	1070.86	53.67
x	742.59	741.88	0.000203	48300	0.0294	733	10966	14.90	66765	3370140	4.49	22.69	1062.53	53.72
	741.38	738.49	0.000220	48400	0.0325	829	12043	14.53	71717	3246374	4.02	24.43	1065.45	49.29
x	739.49	737.75	0.000241	48400	0.0215	614	9079	11.29	45687	3120429	5.33	16.75	1070.74	55.50
	737.75	734.92	0.000171	48500	0.0215	971	10433	10.74	50794	3511790	4.65	21.41	1063.64	43.01
x	734.92	733.94	0.000225	48500	0.0316	713	11360	15.52	60805	3234014	4.39	24.25	1057.27	52.09
	733.94	732.79	0.000210	48600	0.0305	673	10906	16.06	60773	3350229	4.20	23.34	1059.95	53.17
x	732.79	732.30	0.000209	48500	0.0276	612	9027	16.07	62566	3363926	4.95	22.31	1057.56	62.23
	732.30	731.92	0.000191	48700	0.0319	676	11424	16.85	75982	3493655	4.26	25.[illegible]	1055.20	56.21
x	731.92	731.64	0.000195	48700	0.0341	642	11599	18.05	79624	3477170	4.20	25.[illegible]	1055.15	57.66
	731.64	726.51	0.000197	48900	0.0254	662	10087	15.25	62024	3185948	4.85	23.26	1051.49	59.02
x	726.51	725.94	0.000187	48900	0.0250	637	9730	15.27	59896	3553250	5.03	22.43	1052.37	59.54
	725.94	723.99	0.000192	49000	0.0269	633	9896	15.64	61691	3542397	4.95	22.90	1050.63	60.23
x	723.99	723.16	0.000194	49000	0.0251	650	9770	15.03	59501	3518379	5.02	20.99	1051.14	62.64
	723.16	722.32	0.000197	49000	0.0314	634	11093	17.50	74766	3539511	4.42	25.56	1049.42	63.76
x	722.32	721.60	0.000193	49000	0.0279	650	10337	15.89	65313	3479691	4.74	23.52	1046.97	53.69
	721.65	719.33	0.000193	49000	0.0276	647	10322	15.95	65397	3523233	4.75	23.64	1045.35	56.44
x	719.33	718.48	0.000194	49000	0.0246	624	9502	15.27	58346	3519353	5.16	22.[illegible]	1045.78	57.39
	718.48	715.62	0.000198	49000	0.0280	639	10279	16.12	65712	3486331	4.76	24.93	1041.01	52.63
x	716.62	715.97	0.000190	49000	0.0211	646	8722	13.50	47445	3481090	5.62	20.57	1043.96	55.35
	715.97	714.38	0.000201	49000	0.0246	593	9203	15.51	57240	3453570	5.32	22.29	1040.45	54.48
x	714.38	713.63	0.000202	49000	0.0268	624	9864	15.80	62101	3447456	4.97	21.33	1042.37	51.17
	713.63	710.63	0.000199	49000	0.0279	626	10181	16.27	65363	3385722	4.81	22.64	1037.43	53.26
x	710.63	709.89	0.000197	49000	0.0259	616	9625	15.68	60654	3420467	5.06	21.77	1035.51	50.52
	709.89	708.17	0.000209	49000	0.0277	665	10206	15.35	63047	3387655	4.80	21.39	1033.56	50.52
x	708.17	707.72	0.000210	49000	0.0252	633	9446	14.92	57251	3377803	5.19	22.33	1033.42	47.77
	707.72	706.53	0.000205	49000	0.0211	697	8881	12.83	48671	3419729	5.52	22.46	1032.40	47.09
x	706.53	705.89	0.000195	49000	0.0249	629	9567	15.22	58745	3506155	5.12	23.56	1030.31	55.90
	705.89	704.25	0.000194	49000	0.0220	660	9078	13.75	52115	3517874	5.40	21.81	1030.59	53.27
x	704.25	703.57	0.000193	49000	0.0235	624	9260	14.83	55900	3529146	5.29	20.55	1030.73	51.53
	703.57	702.80	0.000202	49000	0.0296	637	10564	16.58	68689	3446246	4.64	25.20	1025.42	49.54
x	702.80	702.35	0.000198	49000	0.0284	645	10429	16.17	66671	3483936	4.70	23.35	1026.77	48.97
	702.35	701.24	0.000196	49000	0.0263	645	9990	15.47	61974	3498047	4.91	26.15	1021.24	50.08
x	701.24	700.62	0.000189	49000	0.0262	625	10083	16.13	64373	3649916	4.86	22.53	1025.76	50.60
	700.62	697.78	0.000193	49000	0.0249	636	9641	15.15	59363	3529582	5.08	23.19	1023.51	54.09
x	697.78	697.15	0.000189	49000	0.0266	657	10238	15.57	63836	3560517	4.79	20.72	1024.21	55.46
	697.15	693.91	0.000193	49000	0.0239	627	9342	14.90	56598	3522667	5.25	22.41	1020.58	53.26
x	693.91	693.20	0.000200	49000	0.0227	630	8995	14.28	52941	3464269	5.45	23.23	1017.70	48.80
	693.20	691.41	0.000193	49000	0.0247	635	9607	15.12	58751	3531050	5.10	24.46	1014.98	49.52
x	691.41	690.85	0.000193	49000	0.0276	630	10222	16.24	65560	3527395	4.79	22.80	1015.67	53.83
	690.85	689.28	0.000198	49000	0.0228	634	9073	14.31	53469	3485096	5.40	24.85	1012.40	45.90
x	689.28	688.56	0.000205	49000	0.0218	638	8743	13.71	50980	3420834	5.60	22.06	1015.06	47.92
	688.56	687.49	0.000205	49100	0.0207	622	8407	13.52	47720	3426584	5.84	22.71	1012.95	47.74
x	687.49	687.02	0.000193	49100	0.0233	620	9110	14.69	54652	3530423	5.39	20.59	1013.75	48.62
	687.32	686.09	0.000187	49100	0.0268	608	9964	16.30	64268	3567783	4.73	26.19	1007.46	45.56
x	686.09	685.53	0.000189	49100	0.0260	623	98[illegible]	15.88	62498	3567783	4.96	22.58	1010.32	51.56
	685.53	683.43	0.000189	49200	0.0255	641	9[illegible]	15.50	61738	3392196	4.95	24.04	1007.57	51.06

	RIVER MILE U/S	RIVER MILE D/S	W.S. U/S	W.S. D/S	D65 FT.	D35 FT.	U* F/S	U*' F/S	U*'' F/S	TAU	R' FT	R'' FT	R'/R	R''/R	N'	N/N'	1/PSI'	J*	PSI'
	753.74	753.30	1104.60	1104.16	0.001043	0.000814	0.245	0.132	0.203	0.137	2.86	7.09	0.207	0.713	0.0120	2.30	0.463	13.93	2.43
x	753.30	752.86	1104.16	1103.71	0.001043	0.000814	0.250	0.131	0.222	0.136	2.75	7.89	0.250	0.732	0.0120	2.47	0.356	13.15	2.52
	752.86	752.15	1103.71	1103.00	0.001047	0.000817	0.257	0.145	0.212	0.130	3.43	7.39	0.317	0.673	0.0122	2.15	0.492	14.69	2.07
x	752.15	751.56	1103.00	1102.40	0.001047	0.000814	0.294	0.140	0.259	0.177	3.15	9.79	0.226	0.774	0.0121	2.69	0.452	12.46	2.21
	751.56	750.03	1102.40	1100.90	0.001047	0.000817	0.314	0.154	0.277	0.135	3.70	11.99	0.236	0.764	0.0122	2.62	0.544	12.92	1.84
x	750.03	747.26	1100.90	1100.00	0.001047	0.000817	0.269	0.155	0.209	0.134	3.79	6.87	0.355	0.645	0.0123	1.99	0.553	13.89	1.81
	747.26	746.24	1100.00	1097.41	0.001050	0.000817	0.318	0.165	0.271	0.199	4.01	10.82	0.271	0.727	0.0123	2.39	0.629	13.95	1.59
x	746.24	745.21	1097.41	1096.58	0.001050	0.000817	0.337	0.153	0.300	0.219	3.35	13.00	0.205	0.795	0.0122	2.88	0.514	11.93	1.87
	745.21	742.59	1096.58	1092.57	0.001053	0.000820	0.314	0.153	0.274	0.192	3.46	11.09	0.238	0.762	0.0122	2.60	0.537	12.89	1.85
x	742.59	741.88	1092.57	1091.80	0.001053	0.000820	0.315	0.164	0.269	0.193	4.06	10.92	0.271	0.729	0.0123	2.39	0.615	13.27	1.62
	741.88	738.49	1091.80	1087.87	0.001056	0.000820	0.321	0.163	0.282	0.202	3.30	11.23	0.227	0.771	0.0122	2.69	0.536	12.54	1.87
x	738.49	737.75	1087.87	1086.93	0.001058	0.000820	0.296	0.195	0.222	0.171	4.91	6.37	0.435	0.565	0.0125	1.74	0.874	19.03	1.14
	737.75	734.92	1086.93	1084.08	0.001060	0.000820	0.257	0.171	0.192	0.131	4.75	5.99	0.443	0.557	0.0129	1.72	0.673	15.12	1.49
x	734.92	733.96	1084.08	1082.94	0.001060	0.000820	0.335	0.165	0.272	0.219	3.75	11.77	0.242	0.758	0.0123	2.58	0.623	13.38	1.60
	733.96	732.79	1082.94	1081.44	0.001063	0.000820	0.333	0.147	0.284	0.212	4.14	11.92	0.258	0.732	0.0124	2.47	0.644	13.64	1.55
x	732.79	732.30	1081.44	1081.13	0.001063	0.000820	0.329	0.181	0.274	0.210	4.87	11.18	0.304	0.676	0.0125	2.21	0.754	13.05	1.33
	732.30	731.92	1081.13	1080.71	0.001063	0.000820	0.325	0.139	0.283	0.207	4.08	12.80	0.240	0.760	0.0125	2.39	0.581	13.13	1.72
x	731.92	731.64	1080.71	1080.42	0.001063	0.000820	0.338	0.157	0.299	0.222	3.91	14.14	0.217	0.783	0.0123	2.77	0.567	12.43	1.76
	731.64	726.51	1080.42	1075.09	0.001065	0.000823	0.311	0.177	0.255	0.187	4.97	10.28	0.326	0.674	0.0125	2.11	0.722	13.60	1.30
x	726.51	725.94	1075.09	1074.52	0.001056	0.000820	0.305	0.182	0.245	0.180	5.45	9.82	0.357	0.643	0.0126	1.99	0.753	16.47	1.31
	725.94	723.99	1074.52	1072.55	0.001070	0.000820	0.310	0.180	0.253	0.187	5.28	10.37	0.337	0.663	0.0126	2.06	0.746	15.95	1.34
x	723.99	723.16	1072.55	1071.70	0.001070	0.000820	0.306	0.182	0.246	0.192	5.33	9.70	0.354	0.645	0.0126	2.00	0.764	16.37	1.31
	723.16	722.32	1071.70	1070.85	0.001073	0.000820	0.327	0.164	0.285	0.207	4.35	13.15	0.249	0.751	0.0124	2.53	0.616	13.44	1.62
x	722.32	721.63	1070.85	1070.18	0.001073	0.000820	0.319	0.174	0.267	0.197	4.74	11.13	0.300	0.700	0.0125	2.23	0.679	14.67	1.43
	721.68	719.33	1070.19	1067.78	0.001076	0.000823	0.315	0.174	0.253	0.194	4.87	11.07	0.306	0.694	0.0125	2.20	0.694	15.35	1.44
x	719.33	718.48	1067.78	1066.91	0.001076	0.000823	0.308	0.187	0.245	0.184	5.59	9.62	0.368	0.632	0.0126	1.95	0.797	15.73	1.25
	718.48	716.62	1066.91	1064.97	0.001079	0.000823	0.329	0.175	0.263	0.200	4.81	11.31	0.299	0.702	0.0125	2.24	0.677	14.56	1.43
x	716.62	715.97	1064.97	1064.29	0.001079	0.000823	0.293	0.201	0.214	0.167	4.35	7.15	0.471	0.527	0.0124	1.65	0.924	19.14	1.09
	715.97	714.38	1064.29	1062.60	0.001083	0.000823	0.317	0.193	0.252	0.197	5.72	9.79	0.369	0.631	0.0127	1.94	0.848	16.79	1.18
x	714.38	713.63	1062.60	1061.90	0.001093	0.000823	0.321	0.182	0.264	0.200	5.08	10.72	0.321	0.679	0.0124	2.13	0.757	15.53	1.32
	713.63	710.63	1061.90	1059.67	0.001084	0.000823	0.322	0.177	0.269	0.201	4.91	11.36	0.302	0.728	0.0125	2.22	0.714	14.96	1.43
x	710.63	709.89	1059.67	1057.90	0.001086	0.000823	0.315	0.184	0.256	0.194	5.35	10.33	0.341	0.659	0.0126	2.05	0.779	16.04	1.29
	709.89	708.17	1057.90	1056.00	0.001087	0.000823	0.322	0.177	0.268	0.201	4.66	10.69	0.303	0.697	0.0125	2.21	0.717	14.93	1.39
x	708.17	707.72	1056.00	1055.50	0.001089	0.000823	0.318	0.189	0.256	0.196	5.28	9.64	0.354	0.646	0.0126	2.03	0.517	15.31	1.22
	707.72	706.53	1055.50	1054.21	0.001093	0.000823	0.291	0.199	0.213	0.165	5.99	6.84	0.467	0.533	0.0127	1.66	0.995	18.95	1.13
x	706.53	705.89	1054.21	1053.55	0.001093	0.000823	0.309	0.186	0.247	0.196	5.51	9.71	0.362	0.638	0.0126	1.97	0.771	16.55	1.25
	705.89	704.25	1053.55	1051.87	0.001093	0.000827	0.293	0.194	0.219	0.166	6.05	7.70	0.440	0.560	0.0127	1.73	0.851	19.41	1.15
x	704.25	703.69	1051.87	1051.30	0.001093	0.000827	0.303	0.171	0.239	0.179	5.89	8.94	0.397	0.603	0.0127	1.85	0.832	17.44	1.20
	703.69	702.90	1051.30	1050.35	0.001096	0.000827	0.328	0.172	0.280	0.209	4.53	12.05	0.273	0.727	0.0125	2.37	0.671	14.12	1.49
x	702.90	702.35	1050.35	1049.88	0.001096	0.000827	0.321	0.173	0.270	0.200	4.72	11.45	0.292	0.708	0.0126	2.27	0.694	14.64	1.46
	702.35	701.24	1049.88	1048.73	0.001096	0.000827	0.313	0.180	0.256	0.190	5.11	10.36	0.330	0.670	0.0126	2.09	0.745	15.79	1.35
x	701.24	700.62	1048.73	1048.14	0.001096	0.000827	0.306	0.177	0.250	0.182	5.40	10.74	0.335	0.665	0.0125	2.08	0.713	15.88	1.40
	700.62	697.78	1048.14	1045.25	0.001099	0.000827	0.307	0.195	0.245	0.183	5.50	9.66	0.363	0.637	0.0128	1.97	0.777	15.57	1.29
x	697.78	697.15	1045.25	1044.62	0.001099	0.000827	0.308	0.175	0.253	0.184	5.05	10.52	0.324	0.676	0.0126	2.12	0.751	15.53	1.43
	697.15	693.91	1044.62	1041.31	0.001102	0.000827	0.305	0.190	0.238	0.180	5.79	9.11	0.389	0.611	0.0127	1.88	0.827	17.22	1.22
x	693.91	693.20	1041.31	1040.56	0.001102	0.000827	0.303	0.197	0.231	0.179	6.00	8.20	0.420	0.569	0.0127	1.78	0.857	17.96	1.14
	693.20	691.41	1040.56	1039.74	0.001106	0.000830	0.308	0.185	0.244	0.182	5.54	9.58	0.366	0.634	0.0127	1.95	0.779	16.66	1.28
x	691.41	690.08	1039.74	1038.20	0.001106	0.000830	0.318	0.176	0.264	0.196	4.98	11.75	0.307	0.693	0.0126	2.20	0.732	15.08	1.43
	690.08	687.28	1038.20	1036.53	0.001109	0.000830	0.302	0.195	0.230	0.177	5.98	8.33	0.418	0.582	0.0127	1.79	0.863	17.90	1.16
x	689.28	688.56	1036.53	1035.75	0.001109	0.000830	0.301	0.202	0.223	0.176	6.16	7.55	0.450	0.553	0.0128	1.75	0.923	18.62	1.08
	688.56	687.49	1035.75	1031.59	0.001112	0.000830	0.299	0.209	0.214	0.173	6.41	6.91	0.489	0.511	0.0128	1.61	0.991	19.53	1.01
x	687.19	687.02	1034.59	1034.11	0.001112	0.000830	0.303	0.194	0.232	0.178	6.07	8.62	0.413	0.587	0.0129	1.80	0.898	17.82	1.17
	687.02	686.09	1034.11	1033.18	0.001115	0.000830	0.316	0.190	0.270	0.194	5.31	11.07	0.324	0.676	0.0126	2.12	0.735	15.59	1.36
x	686.09	685.53	1033.18	1032.62	0.001115	0.000830	0.311	0.181	0.253	0.188	5.38	10.50	0.339	0.661	0.0126	2.06	0.744	15.95	1.34
	685.5	683.43	1032.62	1030.54	0.001119	0.000830	0.304	0.18[illegible]	.247	0.182	5.42	10.09	0.349	0.651	0.0127	2.02	0.740	[illegible]	1.35

	RIVER MILE U/S	RIVER MILE D/S	SLOPE FT/FT	Q CFS	N	TW FT	A SQFT	R FT	AR2/3	K	VEL F/S	MEAN THAL FT	MEAN THAL MSL	[illegible]
X	683.43	682.89	0.000182	49200	0.0272	604	10159	16.81	66669	3643152	4.84	[illegible]	[illegible]	[illegible]
	682.09	681.52	0.000182	49300	0.0242	669	9074	14.75	59399	3649532	4.97	[illegible]	[illegible]	[illegible]
X	681.52	681.15	0.000184	49300	0.0290	644	10802	16.77	70794	3633131	4.56	21.45	[illegible]	[illegible]
	681.16	679.74	0.000193	49300	0.0250	632	9794	15.48	60541	3620765	5.03	[illegible]	[illegible]	44.5?
X	679.74	679.47	0.000182	49300	0.0212	577	8611	14.91	52167	3650597	5.73	21.29	1005.74	56.61
	679.47	677.94	0.000184	49300	0.0224	624	9142	14.65	54745	3630082	5.39	[illegible]	[illegible]	45.33
X	677.94	677.59	0.000197	49300	0.0313	622	11054	17.79	75391	3592116	4.46	[illegible]	[illegible]	49.55
	677.59	676.71	0.000189	49400	0.0272	608	10093	16.59	65511	3509582	4.90	24.70	999.64	47.35
X	676.71	675.45	0.000189	49400	0.0297	555	10128	17.92	69370	3562532	4.88	[illegible]	1000.79	54.72
	676.45	675.13	0.000189	49400	0.0238	627	9252	13.78	62233	3599582	4.97	22.31	1000.24	51.18
X	575.13	674.32	0.000189	49400	0.0309	631	11056	17.53	74690	3509582	4.45	22.34	999.44	57.13
	674.32	672.63	0.000189	49500	0.0283	646	10525	16.44	[illegible]	3607530	4.65	21.19	[illegible]	[illegible]
X	672.63	672.36	0.000199	49500	0.0268	617	10375	15.37	64910	3596349	4.91	[illegible]	[illegible]	[illegible]
	672.35	670.74	0.000191	49600	0.0273	624	10233	16.40	66061	3593042	[illegible]	21.75	993.84	45.69
X	670.74	670.11	0.000192	49600	0.0296	601	10544	17.54	71168	3575967	4.72	[illegible]	[illegible]	59.85
	670.11	665.78	0.000199	49700	0.0252	646	9730	15.14	59048	3522305	5.03	21.75	[illegible]	49.61
X	666.78	666.24	0.000207	49700	0.0241	631	9323	14.77	56113	3454970	5.33	[illegible]	993.55	51.54
	665.24	663.37	0.000182	49800	0.0223	627	9232	14.73	55498	3693054	5.39	21.63	990.27	50.83
X	663.37	662.81	0.000176	49800	0.0203	563	8425	14.97	51230	3755245	5.91	22.80	989.66	52.71
	662.81	660.36	0.000186	49900	0.0260	590	9614	14.63	63996	3663485	5.08	21.72	975.31	46.74
X	660.36	660.40	0.000181	49900	0.0253	608	9248	16.19	63016	3707405	5.07	[illegible]	[illegible]	[illegible]
	660.40	657.75	0.000174	49900	0.0206	629	8940	14.23	52549	3787144	5.50	[illegible]	983.18	49.41
X	657.76	657.40	0.000179	49700	0.0190	612	8093	13.27	45206	3731035	6.17	17.47	[illegible]	[illegible]
	657.40	655.07	0.000173	50000	0.0206	622	8925	14.34	52600	3797726	5.60	21.72	972.12	51.00
X	655.07	654.37	0.000170	50000	0.0232	624	9645	15.45	59822	3829708	5.19	[illegible]	[illegible]	[illegible]
	654.37	651.73	0.000174	50000	0.0240	604	9649	15.97	61178	3786517	5.19	[illegible]	977.30	49.32
X	651.73	651.09	0.000175	50000	0.0228	602	9329	15.49	57929	3781038	5.35	[illegible]	977.47	[illegible]
	551.09	649.37	0.000171	50000	0.0243	617	9857	15.98	62523	3827237	5.07	21.40	972.93	47.71
X	649.37	648.93	0.000165	50000	0.0253	605	10068	16.64	65677	[illegible]	4.97	21.95	[illegible]	54.85
	648.93	644.84	0.000167	50000	0.0224	629	9529	15.16	58350	3872593	5.25	21.51	973.86	51.35
X	644.84	644.11	0.000163	50000	0.0219	593	9245	13.53	57578	3919013	5.41	22.74	972.51	52.79
	644.11	642.06	0.000152	50000	0.0201	535	8700	15.23	54675	4047671	5.52	[illegible]	970.43	53.89
X	642.06	641.41	0.000160	50000	0.0247	569	9951	16.90	65536	3949084	5.02	[illegible]	967.23	47.79
	641.41	639.79	0.000154	50000	0.0269	600	10678	17.80	72737	4024922	4.68	27.22	962.76	46.55
X	639.79	639.22	0.000156	50000	0.0254	583	10157	17.43	68267	4001064	4.92	22.70	946.39	46.46
	639.22	638.50	0.000171	50000	0.0257	631	10285	15.30	66115	3823812	4.86	26.21	942.91	44.07
X	638.50	638.15	0.000157	50000	0.0298	574	11109	19.35	80062	3991370	4.50	26.70	961.17	43.18
	638.15	637.44	0.000155	50000	0.0259	568	10347	17.60	70072	4017779	4.83	28.39	959.33	46.88
X	637.44	636.91	0.000154	50000	0.0234	524	9321	17.78	63492	4033580	5.35	23.35	947.96	52.87
	636.91	634.41	0.000164	50000	0.0222	629	9534	15.15	58376	3908680	5.24	23.56	942.37	48.71
X	634.41	633.47	0.000171	50000	0.0241	610	9757	16.00	61742	3820687	5.12	25.42	959.00	[illegible]
	633.47	632.82	0.000172	50000	0.0139	505	8286	14.16	40503	3913445	6.03	24.97	[illegible]	45.64
X	632.92	632.30	0.000178	50000	0.0265	599	10126	15.92	66733	3742748	4.94	24.41	953.74	54.55
	632.30	631.23	0.000166	50000	0.0241	605	9811	15.21	62834	3376278	5.10	22.00	957.44	45.71
X	631.23	630.79	0.000166	50000	0.0255	632	10307	16.32	66306	3859053	4.85	21.70	959.79	51.39
	630.79	629.90	0.000166	50000	0.0171	640	8178	12.78	44700	3880920	6.11	21.30	959.39	48.56
X	629.90	629.27	0.000174	50000	0.0271	629	10549	15.78	69130	3785546	4.74	23.61	956.91	54.03
	629.27	627.63	0.000165	50000	0.0267	618	10344	17.05	69592	3990918	4.74	24.55	952.05	48.55
X	627.63	627.27	0.000153	50000	0.0215	618	9277	15.04	56690	3915231	5.38	21.39	957.24	49.68
	627.27	623.07	0.000162	50000	0.0204	629	9095	14.46	53936	3924283	5.50	20.55	953.82	47.61
X	623.07	622.66	0.000162	50000	0.0222	608	9442	15.53	59767	3932204	5.30	22.37	952.35	45.61
	622.56	617.55	0.000158	50000	0.0206	610	9192	14.92	55152	3979171	5.47	21.02	950.34	52.28
X	617.55	617.12	0.000172	50000	0.0203	567	8543	15.05	52086	3814950	5.60	21.26	948.82	45.56
	617.12	615.20	0.000158	50000	0.0225	602	9541	15.84	60184	3979950	5.24	21.11	943.76	46.42
X	615.20	614.59	0.000161	50000	0.0212	617	[illegible]	14.97	56187	3935050	5.41	21.41	946.57	45.64

REACHES PRECEDED BY AN X ARE CROSSINGS ALL OTHERS ARE BEND REACHES.

	RIVER MILE - U/S	RIVER MILE D/S	W.S. U/S	W.S. D/S	D55 FT.	D35 FT.	U* F/S	U*' F/S	U*'' F/S	TAU	R' FT	R'' FT	R'/R	R''/R	N'	N/N'	1/PS	*/U*	PSI'
X	683.43	682.89	1030.54	1030.02	0.001119	0.000830	0.314	0.177	0.260	0.171	5.33	11.48	0.317	0.683	0.0125	2.15	0.710	13.41	1.41
	682.89	681.52	1030.02	1029.70	0.001122	0.000833	0.294	0.152	0.232	0.169	5.92	9.13	0.301	0.699	0.0127	1.90	0.745	16.96	1.34
X	681.52	681.16	1028.70	1028.35	0.001122	0.000833	0.315	0.158	0.267	0.173	4.79	11.99	0.285	0.715	0.0125	2.31	0.641	14.47	1.56
	681.15	679.74	1028.33	1026.96	0.001125	0.000833	0.304	0.193	0.243	0.179	5.61	9.07	0.383	0.617	0.0127	1.97	0.757	16.55	1.32
X	679.74	677.47	1026.96	1025.70	0.001125	0.000833	0.296	0.204	0.214	0.170	7.05	7.83	0.473	0.527	0.0129	1.64	0.910	19.35	1.09
	677.47	677.94	1025.70	1025.21	0.001129	0.000833	0.295	0.194	0.222	0.169	6.34	8.31	0.433	0.567	0.0128	1.75	0.852	18.23	1.18
X	677.94	677.59	1025.21	1024.85	0.001129	0.000833	0.329	0.166	0.285	0.211	4.50	13.29	0.253	0.747	0.0125	2.50	0.619	13.53	1.61
	677.59	676.71	1024.86	1023.98	0.001132	0.000833	0.318	0.179	0.263	0.197	5.27	11.32	0.318	0.682	0.0126	2.15	0.725	15.49	1.39
X	676.71	675.45	1023.98	1023.72	0.001132	0.000833	0.331	0.179	0.275	0.212	5.24	12.68	0.292	0.708	0.0126	2.27	0.722	14.76	1.39
	675.45	675.13	1023.72	1022.40	0.001132	0.000833	0.310	0.182	0.251	0.187	5.45	10.33	0.345	0.655	0.0127	2.03	0.750	16.10	1.33
X	675.13	674.32	1022.40	1021.59	0.001132	0.000833	0.327	0.155	0.282	0.200	4.51	13.02	0.257	0.743	0.0125	2.47	0.621	13.65	1.61
	674.32	672.63	1021.59	1019.91	0.001135	0.000837	0.316	0.172	0.265	0.194	4.87	11.56	0.296	0.704	0.0125	2.25	0.654	14.76	1.51
X	672.63	672.35	1019.91	1019.64	0.001135	0.000837	0.315	0.190	0.257	0.193	5.35	11.01	0.325	0.675	0.0127	2.12	0.727	15.58	1.37
	672.35	670.74	1019.54	1019.01	0.001135	0.000837	0.317	0.178	0.253	0.195	5.15	11.25	0.314	0.686	0.0125	2.16	[illegible]	[illegible]	1.41
X	670.74	670.11	1019.01	1017.37	0.001135	0.000837	0.330	0.174	0.230	0.211	4.86	12.67	0.277	0.723	0.0126	2.35	[illegible]	14.27	1.48
	670.11	665.79	1017.37	1013.87	0.001139	0.000837	0.311	0.156	0.252	0.187	5.38	9.76	0.355	0.645	0.0127	1.99	[illegible]	16.31	1.29
X	665.78	666.24	1013.87	1013.29	0.001139	0.000837	0.314	0.194	0.246	0.171	5.65	9.11	0.383	0.617	0.0127	1.93	0.847	17.00	1.18
	665.24	663.37	1013.28	1010.52	0.001139	0.000837	0.294	0.194	0.221	0.158	6.42	8.32	0.436	0.564	0.0129	1.74	[illegible]	18.35	1.10
X	663.37	662.01	1010.52	1010.00	0.001138	0.000837	0.291	0.209	0.213	0.165	7.69	7.28	0.514	0.486	0.0130	1.56	0.932	20.29	1.02
	662.81	660.56	1010.00	1008.09	0.001142	0.000837	0.315	0.195	0.255	0.194	5.72	10.93	0.344	0.656	0.0127	2.04	0.767	16.12	1.35
X	660.56	660.40	1008.09	1007.65	0.001142	0.000837	0.307	0.184	0.245	0.183	5.89	10.39	0.358	0.642	0.0127	1.98	0.761	16.47	1.31
	659.40	657.76	1007.65	1005.23	0.001149	0.000837	0.232	0.199	0.200	0.154	7.09	7.14	0.498	0.502	0.0130	1.59	[illegible]	19.77	1.12
X	657.76	657.40	1005.23	1004.89	0.001145	0.000837	0.276	0.217	0.171	0.148	8.15	5.09	0.618	0.382	0.0131	1.39	[illegible]	22.36	0.95
	657.40	655.37	1004.89	1002.76	0.001148	0.000837	0.283	0.200	0.210	0.155	7.15	7.19	0.499	0.501	0.0130	1.59	[illegible]	19.81	1.11
X	655.37	654.37	1002.76	1002.13	0.001148	0.000837	0.291	0.187	0.223	0.164	6.36	9.09	0.412	0.588	[illegible]	1.81	0.785	[illegible]	1.27
	654.37	651.73	1002.13	999.70	0.001152	0.000840	0.279	0.187	0.234	0.174	6.24	9.73	0.391	0.609	[illegible]	1.87	0.785	17.31	1.27
X	651.73	651.09	999.70	999.11	0.001152	0.000840	0.295	0.193	0.224	0.169	6.59	8.89	0.426	0.574	0.0127	1.77	[illegible]	18.19	1.20
	651.09	649.37	999.11	997.56	0.001158	0.000840	0.296	0.184	0.233	0.170	6.14	9.84	0.384	0.616	0.0128	1.89	[illegible]	17.12	1.32
X	649.37	643.93	997.56	997.17	0.001158	0.000840	0.303	0.180	0.240	0.175	5.99	10.65	0.360	0.640	0.0128	1.98	[illegible]	16.55	1.30
	643.73	644.34	997.17	993.57	0.001161	0.000843	0.265	0.199	0.214	0.158	6.62	8.54	0.437	0.563	0.0129	1.74	0.791	18.40	1.26
X	644.34	641.11	993.57	992.74	0.001161	0.000843	0.285	0.193	0.211	0.159	7.10	8.49	0.455	0.545	0.0130	1.69	[illegible]	[illegible]	1.20
	641.11	642.05	992.94	991.29	0.001165	0.000843	0.273	0.190	0.188	0.145	8.00	7.22	0.525	0.475	0.0131	1.54	[illegible]	20.55	1.14
X	642.06	641.41	991.29	990.74	0.001165	0.000843	0.295	0.191	0.233	0.169	6.38	10.53	0.377	0.623	0.0129	1.92	[illegible]	[illegible]	1.35
	641.41	639.79	990.74	989.42	0.001168	0.000843	0.297	0.170	0.244	0.172	5.84	11.76	0.332	0.668	0.0127	2.10	0.647	15.75	1.54
X	639.79	639.22	989.42	988.95	0.001168	0.000843	0.296	0.178	0.237	0.170	6.29	11.14	0.361	0.639	[illegible]	1.97	[illegible]	16.63	1.42
	639.22	638.50	988.95	988.30	0.001168	0.000843	0.300	0.177	0.242	0.174	5.70	10.60	0.350	0.650	0.0128	2.01	[illegible]	16.23	1.43
X	638.50	638.15	988.30	988.01	0.001168	0.000843	0.313	0.165	0.266	0.190	5.39	13.96	0.278	0.722	0.0127	2.35	[illegible]	14.40	1.65
	638.15	637.44	988.01	987.43	0.001171	0.000843	0.295	0.175	0.239	0.169	6.14	11.46	0.349	0.651	0.0128	2.02	[illegible]	16.32	1.46
X	637.44	636.91	987.43	987.00	0.001171	0.000843	0.297	0.191	0.227	0.170	7.35	10.40	0.415	0.585	0.0130	1.80	[illegible]	18.07	1.23
	636.91	634.41	987.00	984.84	0.001175	0.000843	0.283	0.198	0.211	0.155	6.73	8.42	0.444	0.556	0.0129	1.72	[illegible]	18.55	1.26
X	634.41	633.47	984.84	983.99	0.001175	0.000843	0.297	0.193	0.232	0.172	6.24	9.76	0.390	0.610	0.0129	1.87	[illegible]	17.25	[illegible]
	633.47	632.82	983.99	983.40	0.001178	0.000846	0.280	0.213	0.162	0.152	8.17	5.99	0.577	0.423	0.0131	1.44	[illegible]	21.55	0.99
X	632.82	632.30	983.40	982.91	0.001178	0.000846	0.312	0.139	0.254	0.188	5.69	11.27	0.334	0.666	0.0127	2.08	[illegible]	15.84	1.35
	632.30	631.23	982.91	981.97	0.001181	0.000846	0.295	0.184	0.230	0.169	6.34	9.07	0.391	0.609	0.0129	1.87	[illegible]	17.27	1.32
X	631.23	630.79	981.97	981.59	0.001181	0.000846	0.297	0.177	0.239	0.172	5.78	10.54	0.354	0.646	0.0128	2.00	[illegible]	16.31	1.44
	630.79	629.90	981.58	980.80	0.001181	0.000846	0.261	0.215	0.149	0.133	8.61	4.17	0.674	0.326	0.0132	1.30	1.224	23.39	0.93
X	629.90	629.27	980.80	980.22	0.001181	0.000846	0.307	0.174	0.253	0.183	5.38	11.39	0.321	0.679	0.0127	2.13	[illegible]	15.44	1.49
	629.27	627.63	980.22	978.79	0.001184	0.000850	0.301	0.173	0.246	0.176	5.64	11.42	0.331	0.669	0.0128	2.07	[illegible]	15.74	1.52
X	627.63	627.27	978.79	978.48	0.001184	0.000850	0.281	0.193	0.205	0.154	7.06	7.99	0.469	0.531	0.0130	1.66	0.821	19.13	1.22
	627.27	623.07	978.48	974.88	0.001187	0.000850	0.275	0.194	0.193	0.147	7.32	7.13	0.506	0.494	0.0130	1.57	[illegible]	19.97	1.15
X	623.07	622.66	974.88	974.53	0.001188	0.000850	0.284	0.190	0.212	0.157	6.92	8.60	0.446	0.554	0.0130	1.71	[illegible]	18.63	1.25
	622.66	617.55	974.53	970.27	0.001191	0.000853	0.275	0.195	0.194	[illegible]	7.49	7.43	0.502	0.498	0.0130	1.58	[illegible]	19.95	1.19
X	617.55	617.12	970.27	957.88	0.001191	0.000853	0.267	0.207	0.201	[illegible]	7.77	7.29	0.516	0.484	0.0131	1.55	0.947	20.25	1.05
	617.12	615.20	969.83	968.28	0.001197	0.000853	0.284	0.138	0.213	[illegible]	6.95	8.89	0.439	0.561	0.0130	1.73	0.782	13.47	1.28
X	615.2[illegible]	614.59	968.28	967.76	0.001197	0.000853	0.279	0.194	0.201	0.151	7.20	7.77	0.481	0.519	0.0130	1.63	0.825	[illegible].36	1.21

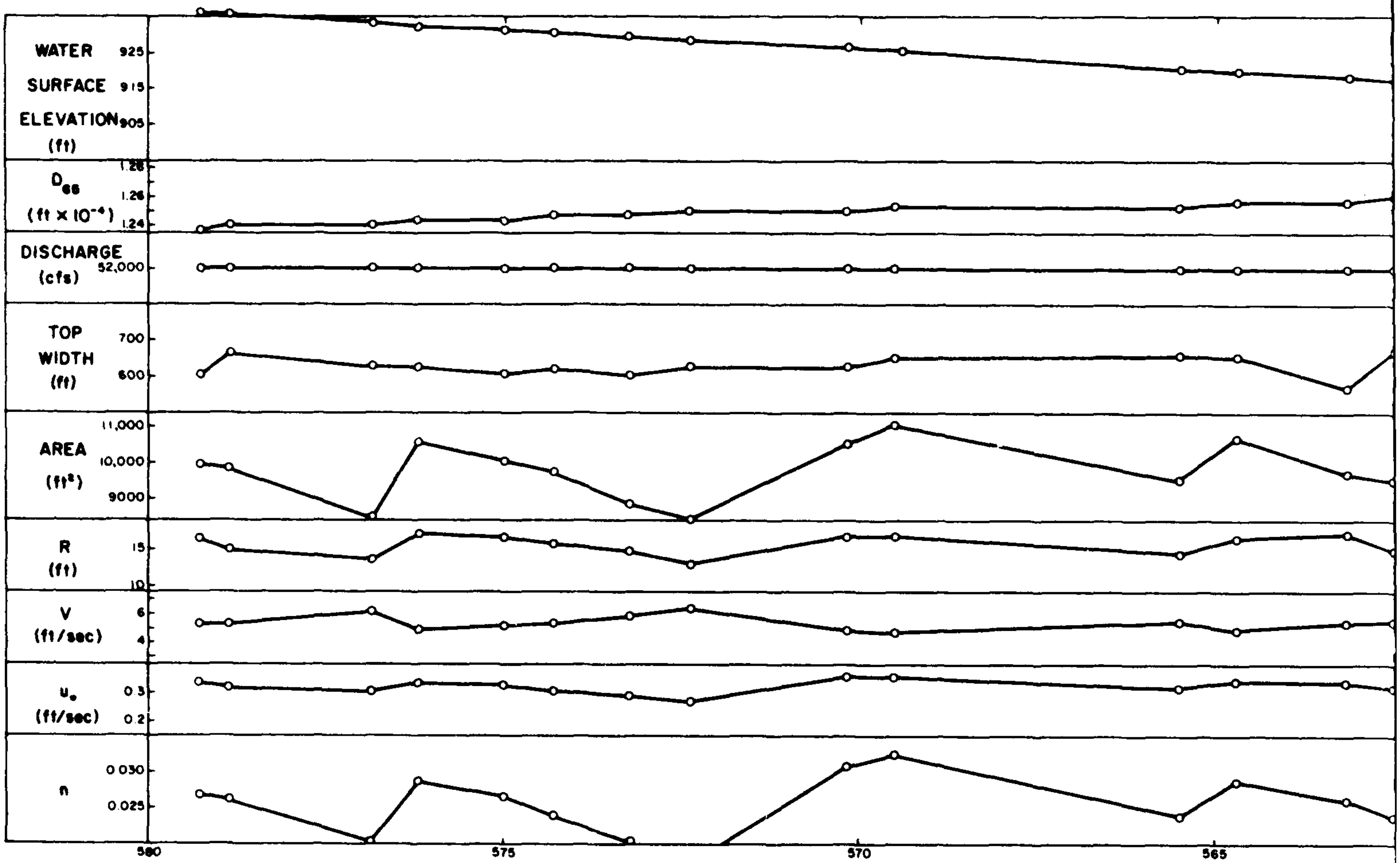
* [illegible] X [illegible] ARE CROSSINGS ALL OTHERS ARE BEND REACHES

1971 MISSOURI RIVER HYDR. [illegible] FROM SIOUX CITY [illegible]

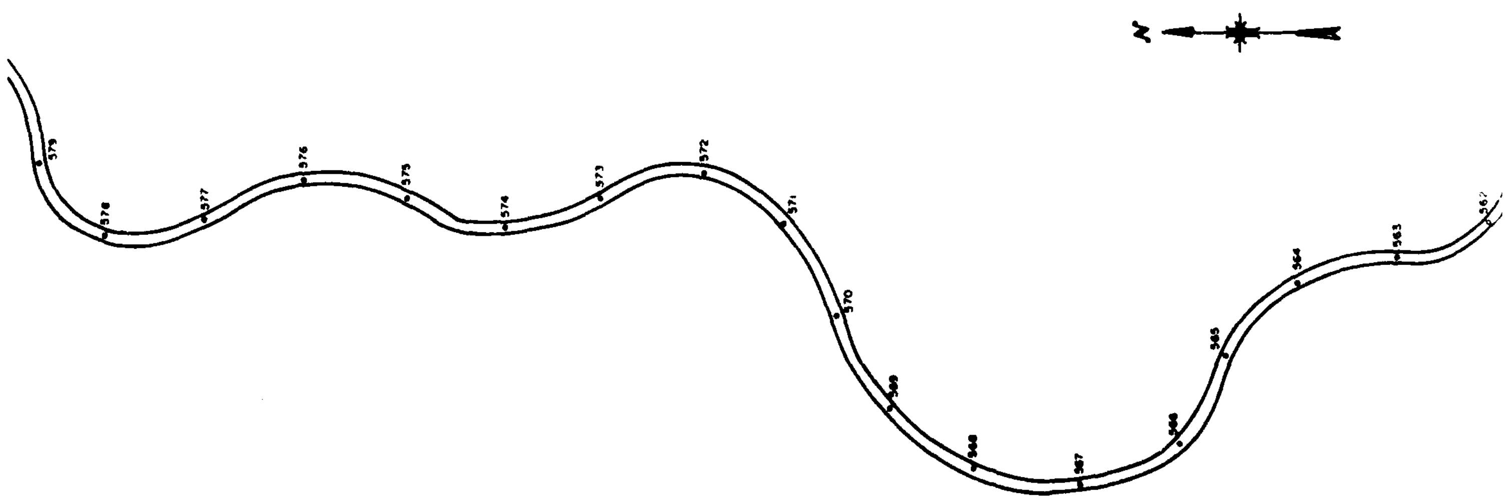
	RIVER MILE U/S	RIVER MILE D/S	SLOPE FT/FT	Q CFS	N	TW FT	AREA SQFT	R FT	AR2/3	K	VEL F/S	MEAN THAL FT	MEAN THAL MSL	PCT BELOW MEAN
	614.59	613.09	0.000162	50000	0.0212	586	9038	15.43	56014	3933033	5.53	23.26	943.87	51.18
X	613.09	612.34	0.000159	50000	0.0232	575	9513	16.54	61761	3964125	5.26	23.72	942.38	54.61
	612.34	609.63	0.000159	50300	0.0202	623	9093	14.60	54318	3993527	5.53	25.08	939.50	48.49
X	609.63	606.74	0.000158	50300	0.0179	603	8352	13.84	48151	4002445	6.02	23.08	942.54	57.47
	606.74	604.52	0.000153	50500	0.0182	612	8522	13.92	47316	4027709	5.94	24.77	915.47	46.75
X	604.52	603.87	0.000157	50600	0.0155	611	7747	12.67	42116	4033920	6.53	23.47	915.34	48.74
	603.87	600.94	0.000159	50900	0.0211	580	9136	15.74	57359	4036463	5.57	24.31	933.21	49.57
X	600.94	600.38	0.000166	50900	0.0265	582	8860	15.23	54448	3953746	5.74	20.70	935.20	52.73
	600.38	599.54	0.000149	51100	0.0207	601	9355	15.57	58318	4188953	5.46	23.18	932.42	48.28
X	599.54	598.89	0.000151	51100	0.0202	538	8771	15.31	56412	4150414	5.83	24.15	910.83	46.89
	598.89	598.24	0.000149	51400	0.0173	594	8401	14.14	49117	4213546	6.12	21.72	932.63	53.06
X	598.24	597.77	0.000149	51400	0.0163	595	8096	13.61	46140	4209477	6.35	20.45	931.51	55.36
	597.77	596.53	0.000133	51700	0.0178	561	8667	15.46	53777	4314962	5.97	23.75	929.37	48.59
X	596.53	595.96	0.000126	51700	0.0166	569	8400	14.91	51382	4501010	6.19	20.30	932.72	51.55
	595.96	594.80	0.000157	52000	0.0177	626	8434	13.67	48665	4329482	6.17	24.11	927.23	47.11
X	594.80	593.75	0.000198	52000	0.0192	645	8541	13.23	47780	3591434	6.09	20.45	930.09	53.00
	593.75	591.97	0.000199	52000	0.0188	596	8157	13.69	46676	3686460	6.37	23.31	926.46	47.73
X	591.97	591.49	0.000185	52000	0.0202	615	8802	14.31	51583	3818423	5.91	23.52	924.68	45.78
	591.49	589.29	0.000188	52000	0.0178	617	8142	13.20	45479	3795101	6.39	22.50	924.47	49.23
X	589.29	588.91	0.000189	52000	0.0155	600	7401	12.33	37507	3778508	7.03	18.87	925.82	50.94
	588.91	586.43	0.000174	52000	0.0170	611	8073	13.21	45112	3940749	6.44	19.53	924.83	48.94
X	586.43	585.86	0.000173	52000	0.0149	560	7216	12.89	39683	3955950	7.20	18.71	925.25	41.99
	585.86	582.83	0.000176	52000	0.0221	594	9311	15.67	58302	3923434	5.58	21.23	923.09	51.94
X	582.83	582.17	0.000178	52000	0.0242	592	9476	15.02	60213	3495453	5.49	22.92	916.70	46.10
	582.17	579.28	0.000198	52000	0.0243	612	9621	15.73	60403	3696238	5.40	22.15	915.57	54.07
X	579.28	578.89	0.000213	52000	0.0258	607	9944	16.39	64162	3542411	5.23	22.30	913.41	44.88
	578.89	576.89	0.000214	52000	0.0250	661	9866	14.93	59815	3554173	5.27	24.32	910.53	46.73
X	576.89	576.21	0.000215	52000	0.0201	626	8468	13.52	46064	3517733	6.14	19.34	913.75	53.60
	575.21	574.99	0.000203	52000	0.0265	622	10587	17.62	70039	3546402	4.91	24.33	907.73	53.39
X	574.99	574.32	0.000194	52000	0.0263	606	10051	16.57	65306	3696653	5.17	24.60	906.44	49.54
	574.32	573.24	0.000198	52000	0.0239	620	9734	15.70	61032	3796123	5.34	22.86	907.31	53.07
X	573.24	572.38	0.000176	52000	0.0203	602	8676	14.75	53388	3917640	5.86	20.95	907.17	57.77
	572.38	570.17	0.000175	52000	0.0170	628	8134	12.95	44866	3932795	6.39	19.59	908.22	49.10
X	570.17	569.39	0.000243	52000	0.0308	626	10536	16.84	69227	3317088	4.94	22.19	903.89	51.23
	569.39	565.59	0.000241	52000	0.0323	654	11056	16.89	72792	3349597	4.70	23.27	900.01	52.83
X	565.59	564.69	0.000217	52000	0.0233	659	9512	14.43	58382	3526317	5.47	18.39	901.48	54.59
	564.69	563.15	0.000212	52000	0.0257	653	10693	16.37	68944	3575333	4.86	22.48	894.53	52.39
X	563.15	562.51	0.000201	52000	0.0260	569	9677	17.01	64014	3665691	5.37	22.20	895.62	52.77
	562.51	560.49	0.000210	52000	0.0238	639	9502	14.88	57476	3588161	5.47	22.97	893.47	47.53
X	560.49	559.76	0.000213	52000	0.0239	593	9203	15.51	57237	3565125	5.65	21.27	893.58	49.10
	559.76	556.77	0.000213	52000	0.0252	630	9733	15.44	60351	3544399	5.34	21.11	891.63	53.59
X	556.77	556.24	0.000204	52000	0.0258	627	10003	15.95	63381	3513517	5.20	21.54	889.26	53.27
	556.24	555.64	0.000206	52000	0.0270	642	10305	16.04	65539	3602666	5.05	26.08	884.13	45.19
X	555.64	554.85	0.000204	52000	0.0253	618	9819	15.59	62059	3542708	5.30	22.46	886.90	52.47
	554.85	552.91	0.000208	52000	0.0239	674	9756	14.47	57928	3506047	5.33	21.93	886.03	49.62
X	552.91	552.36	0.000220	52000	0.0335	607	11269	18.56	78799	3502770	4.61	22.93	883.73	48.26
	552.36	550.97	0.000215	52000	0.0339	608	10824	17.80	73784	3544044	4.80	26.44	879.01	43.19
X	550.97	550.23	0.000218	52000	0.0287	619	10383	16.73	68045	3525549	5.01	22.57	881.67	54.33
	550.23	549.49	0.000215	52000	0.0322	606	11074	18.29	76862	3546472	4.70	25.12	878.08	45.49
X	549.49	549.10	0.000204	52000	0.0318	628	11238	18.05	78073	3641061	4.59	25.32	877.44	45.22
	549.10	546.29	0.000206	52000	0.0274	634	10365	16.36	66792	3620868	5.02	24.37	876.44	50.10
X	546.29	545.91	0.000204	52000	0.0330	598	10730	17.93	73508	3637644	4.85	23.95	875.33	50.22
	545.91	544.80	0.000212	52000	0.0290	728	11257	15.47	69887	3574958	4.62	26.41	872.05	46.49
X	544.80	544.24	0.000210	52000	0.0282	634	104[illegible]	16.54	68097	3591025	4.96	22.27	875.26	50.77
	544.24	543.58	0.000207	52000	0.0248	672	9[illegible]	14.87	60461	3617646	5.20	22.32	874.54	47.41

1971 MISSOURI RIVER HYD... FROM SIOUX CITY TO [illegible]

	RIVER MILE U/S	RIVER MILE D/S	W.S. U/S	W.S. D/S	D65 FT.	D35 FT.	U* F/S	U*' F/S	U*'' F/S	TAU	R' FT	R'' FT	R'/R	R''/R	N'	N/N'	1/PSI'	V/U*	PSI'
	614.59	613.09	957.76	965.48	0.001201	0.000853	0.283	0.197	0.203	0.156	7.45	7.95	0.485	0.515	0.0131	1.62	0.852	19.52	1.16
x	613.09	612.34	965.48	965.85	0.001201	0.000853	0.291	0.189	0.222	0.164	6.95	9.60	0.420	0.580	0.0130	1.78	0.785	18.05	1.27
	612.34	609.63	965.85	963.58	0.001204	0.000856	0.273	0.197	0.170	0.145	7.56	7.04	0.518	0.482	0.0130	1.55	0.849	20.26	1.15
x	609.63	606.74	963.58	961.17	0.001234	0.000856	0.265	0.211	0.160	0.138	8.78	5.06	0.635	0.365	0.0132	1.35	0.932	22.73	1.02
	606.74	604.52	961.17	959.32	0.001207	0.000856	0.266	0.207	0.169	0.138	8.57	5.35	0.616	0.384	0.0132	1.38	0.924	22.32	1.04
x	604.52	603.87	959.32	958.76	0.001207	0.000856	0.253	0.226	0.114	0.125	10.11	2.56	0.798	0.202	0.0133	1.16	1.126	25.77	0.89
	603.87	600.94	958.76	956.32	0.001211	0.000860	0.284	0.198	0.203	0.157	7.49	8.06	0.488	0.512	0.0131	1.61	0.861	19.62	1.16
x	600.94	600.38	956.32	955.83	0.001211	0.000860	0.285	0.204	0.197	0.157	7.78	7.45	0.511	0.489	0.0131	1.56	0.910	20.15	1.19
	600.38	599.54	955.83	955.17	0.001214	0.000863	0.273	0.194	0.192	0.145	7.84	7.73	0.503	0.497	0.0131	1.58	0.819	20.09	1.22
x	599.54	598.80	955.17	954.58	0.001214	0.000863	0.282	0.205	0.193	0.154	8.63	7.68	0.529	0.471	0.0132	1.53	0.915	20.69	1.09
	598.80	598.24	954.58	954.14	0.001217	0.000863	0.260	0.213	0.149	0.132	9.51	4.63	0.672	0.328	0.0133	1.30	0.994	23.51	1.01
x	598.24	597.77	954.14	953.77	0.001217	0.000863	0.256	0.220	0.130	0.127	10.10	3.50	0.743	0.257	0.0134	1.22	1.058	24.84	0.95
	597.77	596.53	953.77	952.90	0.001220	0.000863	0.257	0.207	0.152	0.129	10.03	5.42	0.649	0.351	0.0134	1.33	0.936	23.20	1.07
x	596.53	595.96	952.90	952.52	0.001220	0.000863	0.246	0.210	0.128	0.118	10.87	4.05	0.729	0.271	0.0134	1.23	0.944	24.76	1.04
	595.96	594.80	952.52	951.90	0.001224	0.000863	0.270	0.217	0.161	0.142	8.74	4.84	0.644	0.355	0.0132	1.34	1.027	22.83	0.99
x	594.80	593.75	951.90	950.40	0.001224	0.000863	0.291	0.217	0.193	0.155	7.39	5.84	0.559	0.442	0.0130	1.47	1.033	20.71	0.97
	593.75	591.97	950.40	948.53	0.001227	0.000866	0.296	0.226	0.191	0.171	7.97	5.72	0.582	0.418	0.0131	1.43	1.127	21.53	0.93
x	591.97	591.49	948.53	948.06	0.001227	0.000866	0.292	0.211	0.203	0.166	7.43	6.88	0.519	0.481	0.0130	1.55	0.924	20.21	1.34
	591.49	589.29	948.06	945.88	0.001227	0.000866	0.282	0.225	0.170	0.155	8.41	4.80	0.637	0.363	0.0132	1.35	1.124	22.51	0.91
x	587.29	586.91	945.88	945.50	0.001227	0.000866	0.274	0.244	0.124	0.146	7.80	2.53	0.795	0.205	0.0133	1.17	1.297	25.62	0.77
	588.51	586.43	945.50	943.22	0.001230	0.000866	0.272	0.226	0.152	0.144	9.09	4.12	0.688	0.312	0.0133	1.28	1.159	23.67	0.90
x	585.43	585.56	943.22	942.70	0.001230	0.000866	0.260	0.248	0.100	0.139	11.08	1.81	0.859	0.141	0.0135	1.11	1.339	26.30	0.75
	585.86	582.83	942.70	937.89	0.001234	0.000935	0.293	0.201	0.270	0.172	7.11	8.55	0.454	0.546	0.0130	1.69	0.810	18.75	1.23
x	582.83	582.17	937.89	939.20	0.001234	0.000867	0.320	0.179	0.250	0.201	6.74	9.78	0.390	0.611	0.0129	1.87	0.851	17.17	1.15
	582.17	579.28	939.20	936.18	0.001237	0.000869	0.317	0.197	0.248	0.195	6.09	9.64	0.387	0.613	0.0129	1.88	0.842	17.27	1.19
x	579.28	578.80	936.18	935.64	0.001237	0.000869	0.335	0.193	0.275	0.219	5.40	10.99	0.330	0.671	0.0128	2.10	0.803	15.59	1.25
	578.80	576.58	935.64	933.47	0.001240	0.000869	0.321	0.194	0.256	0.200	5.45	9.48	0.365	0.635	0.0128	1.94	0.813	16.43	1.23
x	576.88	576.21	933.47	932.71	0.001240	0.000869	0.306	0.220	0.212	0.191	7.01	6.51	0.519	0.451	0.0130	1.55	1.050	22.05	0.73
	576.21	574.99	932.71	931.40	0.001243	0.000869	0.334	0.182	0.280	0.217	5.04	11.95	0.297	0.703	0.0127	2.24	0.716	14.71	1.39
x	574.99	574.32	931.40	930.70	0.001243	0.000869	0.325	0.170	0.264	0.206	5.65	10.74	0.341	0.659	0.0128	2.05	0.785	15.91	1.29
	574.32	573.24	930.70	929.63	0.001247	0.000867	0.308	0.194	0.239	0.184	6.25	9.45	0.358	0.642	0.0129	1.85	0.817	17.35	1.22
x	573.24	572.39	929.63	928.83	0.001247	0.000869	0.267	0.208	0.209	0.163	7.46	7.08	0.520	0.480	0.0131	1.55	0.941	20.25	1.06
	572.38	570.17	928.83	926.79	0.001250	0.000867	0.272	0.225	0.150	0.142	8.96	3.99	0.692	0.308	0.0133	1.29	1.173	23.57	0.92
x	570.17	569.37	926.79	925.79	0.001250	0.000869	0.363	0.185	0.312	0.255	4.40	12.44	0.261	0.739	0.0124	2.45	0.745	13.60	1.34
	569.39	565.50	925.79	920.84	0.001253	0.000869	0.362	0.178	0.315	0.256	4.09	12.81	0.242	0.758	0.0125	2.58	0.657	12.99	1.46
x	565.50	564.69	920.84	919.91	0.001253	0.000869	0.318	0.200	0.247	0.196	5.74	8.69	0.398	0.602	0.0129	1.85	0.872	17.23	1.15
	564.69	563.15	917.71	918.19	0.001257	0.000873	0.334	0.181	0.250	0.217	4.82	11.55	0.295	0.705	0.0127	2.26	0.729	14.58	1.41
x	563.15	562.51	918.19	917.51	0.001257	0.000873	0.332	0.196	0.268	0.214	5.95	11.06	0.350	0.650	0.0129	2.01	0.822	16.18	1.23
	562.51	560.49	917.51	915.27	0.001260	0.000873	0.317	0.200	0.246	0.175	5.93	8.95	0.398	0.602	0.0129	1.85	0.864	17.25	1.16
x	560.49	557.76	915.27	911.45	0.001260	0.000873	0.326	0.206	0.253	0.207	6.19	9.32	0.399	0.601	0.0129	1.65	0.914	17.33	1.39
	557.76	556.77	914.45	911.09	0.001263	0.000873	0.325	0.196	0.259	0.206	5.42	9.82	0.364	0.636	0.0128	1.96	0.831	16.42	1.20
x	556.77	556.24	911.09	910.52	0.001263	0.000873	0.323	0.191	0.261	0.204	5.57	10.39	0.349	0.651	0.0128	2.02	0.759	15.97	1.27
	556.24	555.64	910.52	909.86	0.001256	0.000873	0.328	0.187	0.270	0.210	5.20	10.84	0.324	0.676	0.0128	2.12	0.751	15.38	1.33
x	555.64	554.85	909.86	909.01	0.001266	0.000873	0.323	0.194	0.258	0.202	5.75	10.14	0.362	0.638	0.0129	1.97	0.814	16.40	1.23
	554.85	552.91	909.01	906.88	0.001270	0.000873	0.311	0.196	0.242	0.190	5.72	8.74	0.396	0.604	0.0129	1.86	0.875	17.12	1.21
x	552.91	552.36	906.88	906.24	0.001270	0.000873	0.363	0.174	0.318	0.255	4.28	14.28	0.230	0.770	0.0126	2.66	0.655	12.71	1.53
	552.36	550.97	906.24	904.66	0.001273	0.000873	0.351	0.180	0.302	0.240	4.67	13.13	0.262	0.739	0.0127	2.44	0.698	13.68	1.43
x	550.97	550.23	904.66	903.81	0.001273	0.000873	0.343	0.186	0.288	0.229	4.96	11.82	0.296	0.704	0.0127	2.25	0.747	14.61	1.33
	550.23	549.49	903.81	902.97	0.001276	0.000873	0.356	0.176	0.309	0.246	4.50	13.79	0.246	0.751	0.0126	2.55	0.672	13.23	1.49
x	549.49	549.10	902.97	902.55	0.001276	0.000873	0.344	0.172	0.275	0.229	4.52	13.53	0.250	0.750	0.0127	2.52	0.640	13.32	1.56
	549.10	546.29	902.55	899.49	0.001280	0.000876	0.330	0.186	0.272	0.212	5.21	11.15	0.318	0.682	0.0128	2.15	0.743	15.22	1.35
x	546.29	545.91	899.49	899.08	0.001280	0.000876	0.343	0.181	0.292	0.229	4.95	12.98	0.276	0.724	0.0127	2.36	0.700	14.11	1.43
	545.91	544.80	899.08	897.84	0.001283	0.000876	0.325	0.174	0.274	0.206	4.44	11.03	0.287	0.713	0.0126	2.30	0.649	14.23	1.54
x	544.80	44.24	897.84	897.22	0.001283	0.000876	0.334	0.194	279	0.218	5.03	11.51	0.304	0.696	0.0127	2.21	0.730	83	1.37
	544.24	13.50	897.22	896.50	0.001286	0.000875	0.315	0.192	19	0.191	5.52	9.34	0.372	0.628	0.0128	1.94	0.790	53	1.27



WATER SURFACE ELEVATION (ft)
925
915
905
D_{65} (ft × 10^{-4})
1.28
1.26
1.24
DISCHARGE (cfs)
52,000
TOP WIDTH (ft)
700
600
AREA (ft²)
11,000
10,000
9000
R (ft)
15
10
V (ft/sec)
6
4
u_* (ft/sec)
0.3
0.2
n
0.030
0.025
580
575
570
565



N
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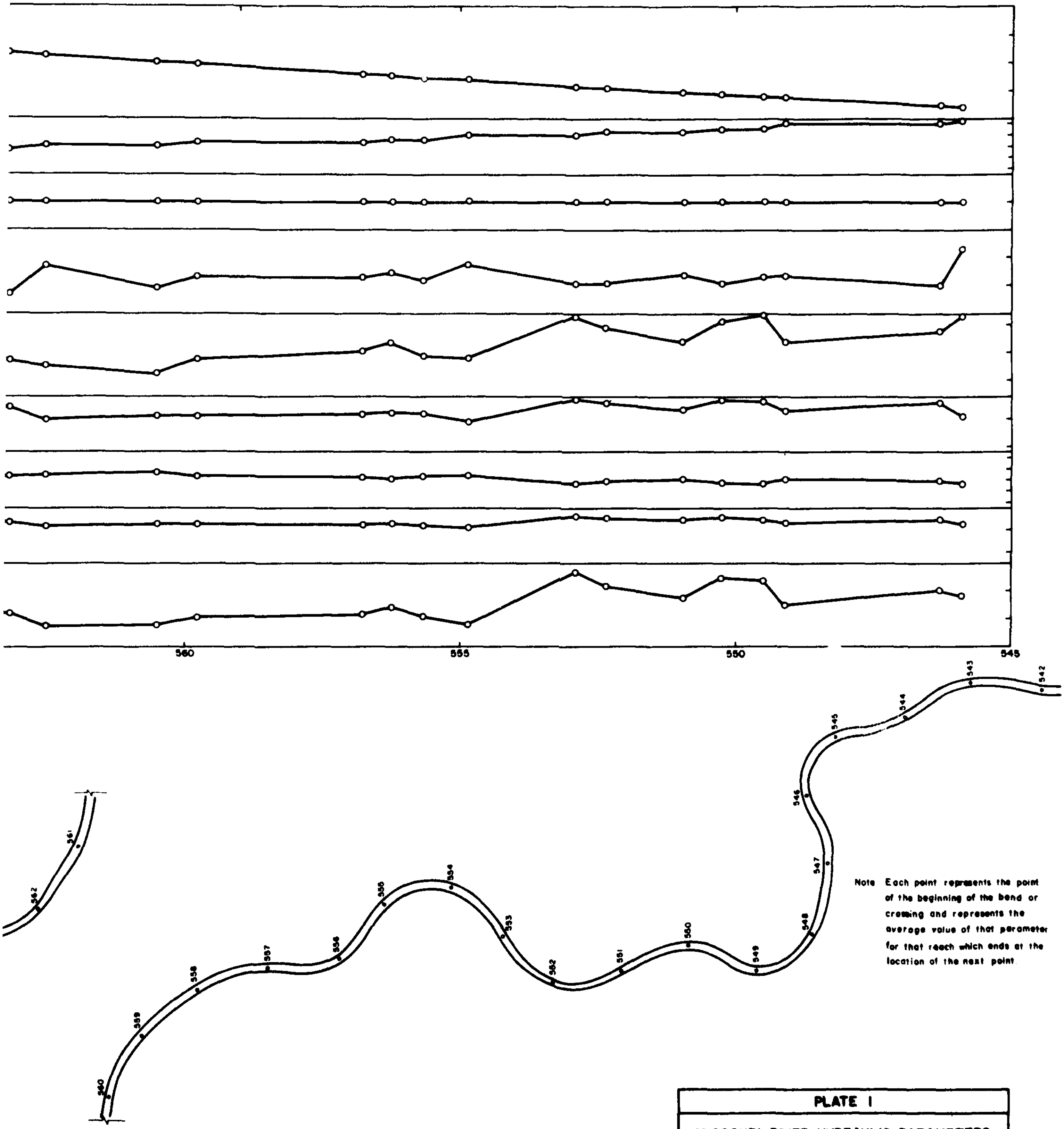
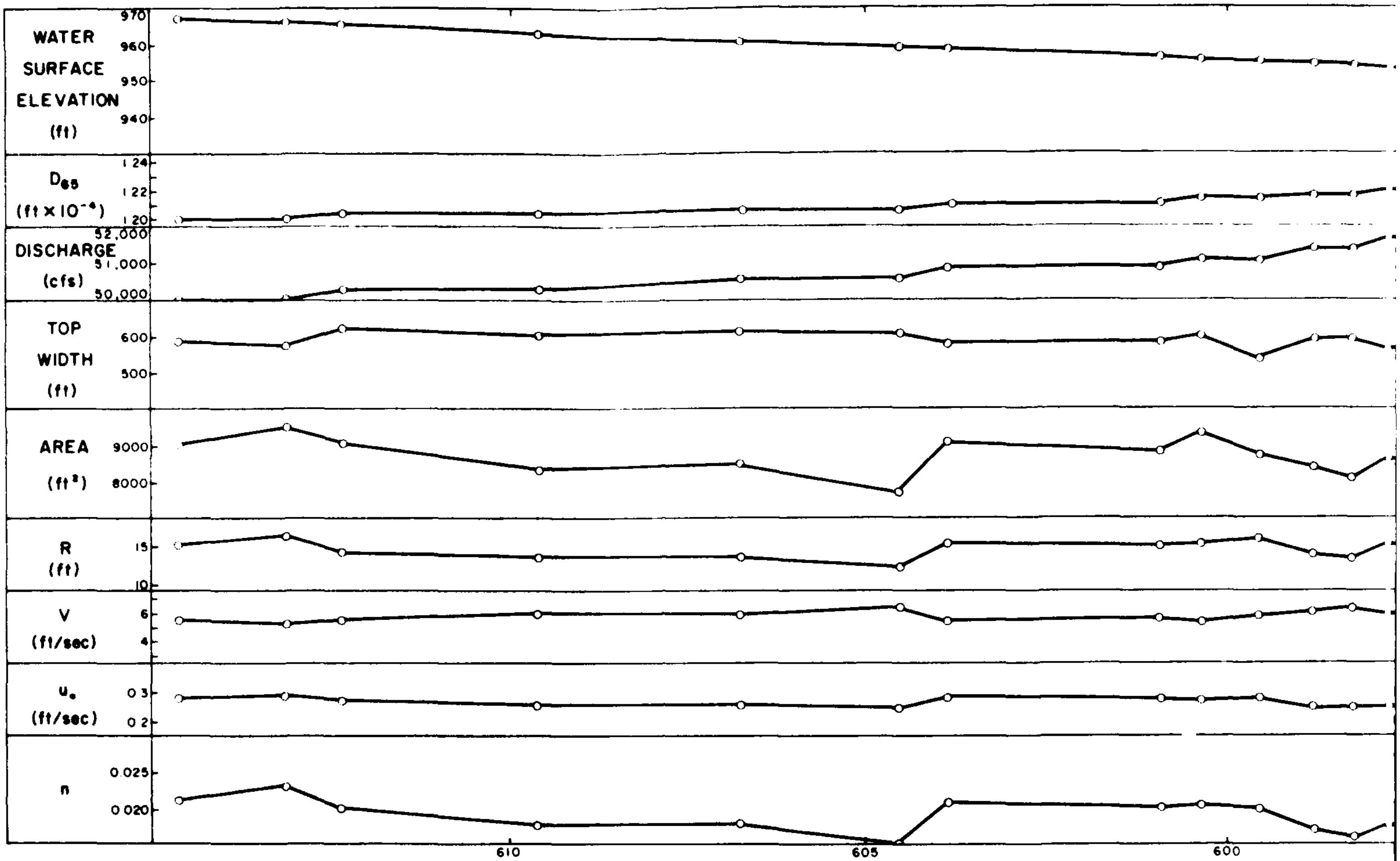


Note: Each point represents the point of the beginning of the bend or crossing and represents the average value of that parameter for that reach which ends at the location of the next point.

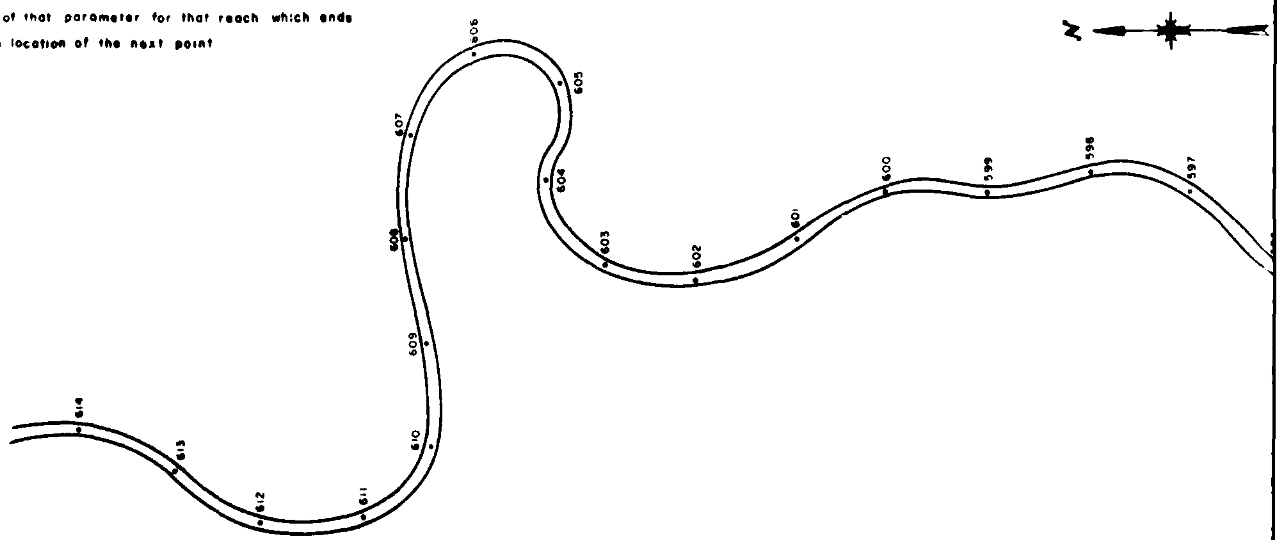
PLATE I

MISSOURI RIVER HYDRAULIC PARAMETERS (FROM 1971 HYDROGRAPHIC SURVEY)

2



Note Each point represents the point of the beginning of the bend or crossing and represents the average value of that parameter for that reach which ends at the location of the next point



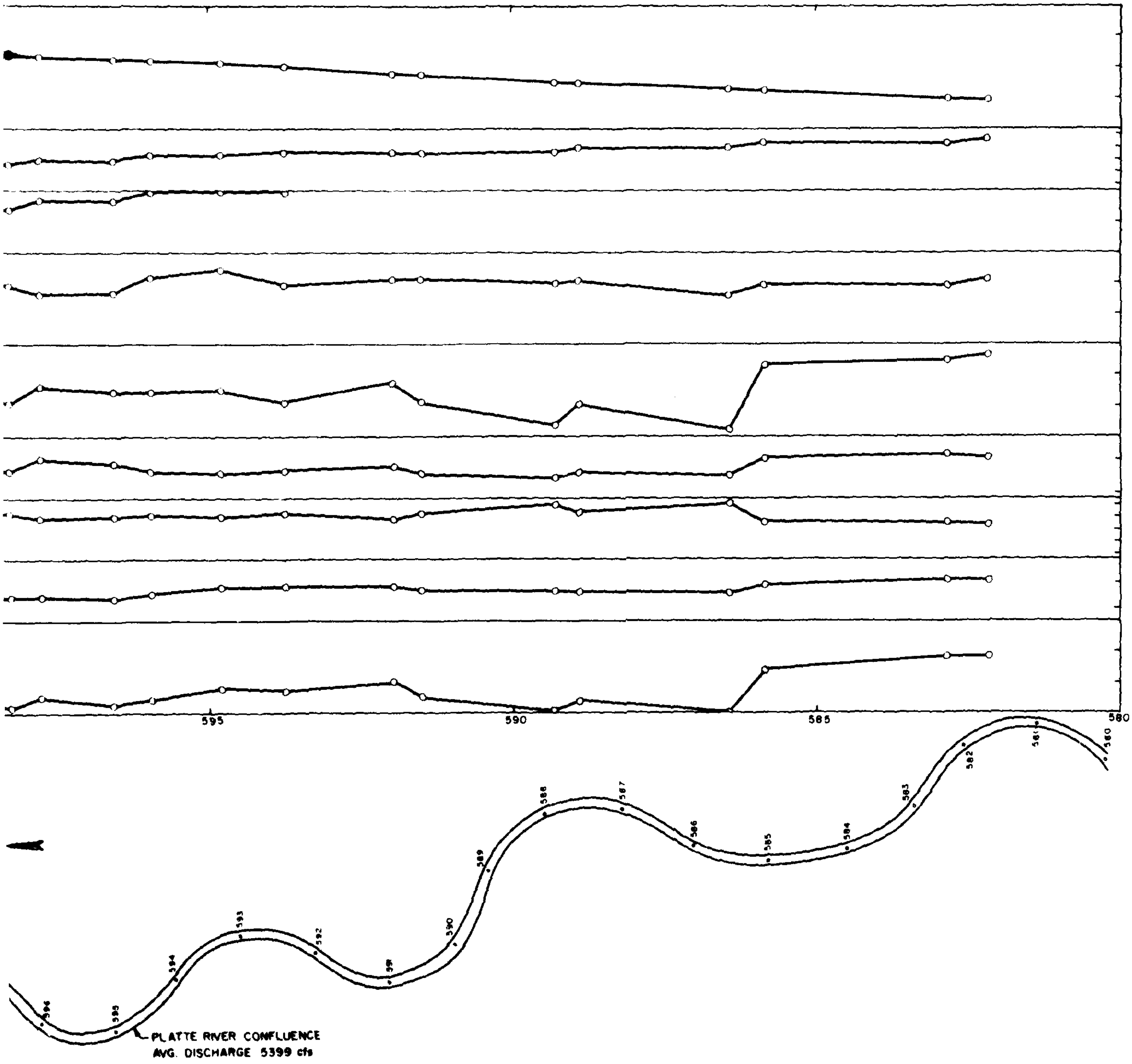
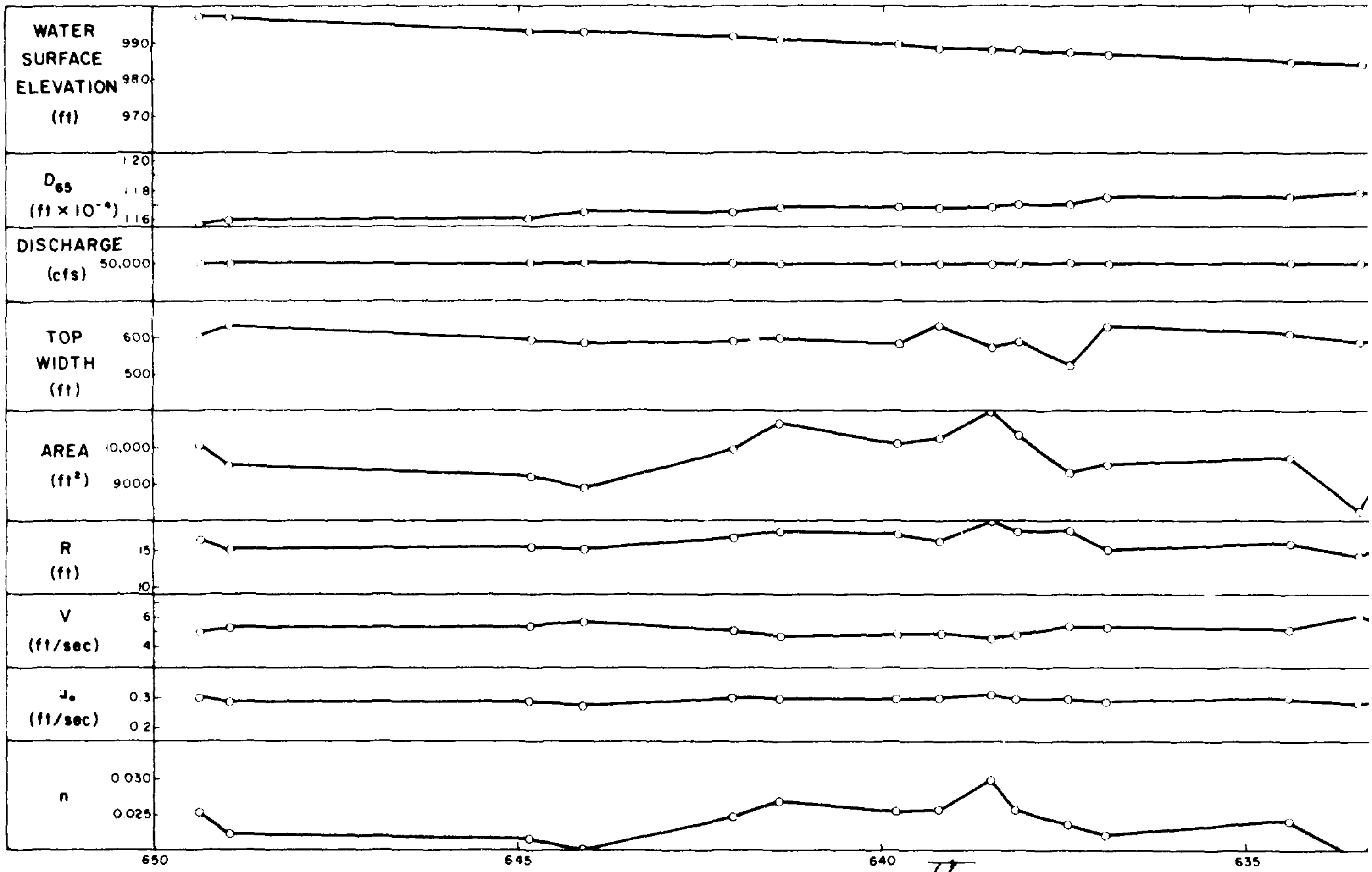
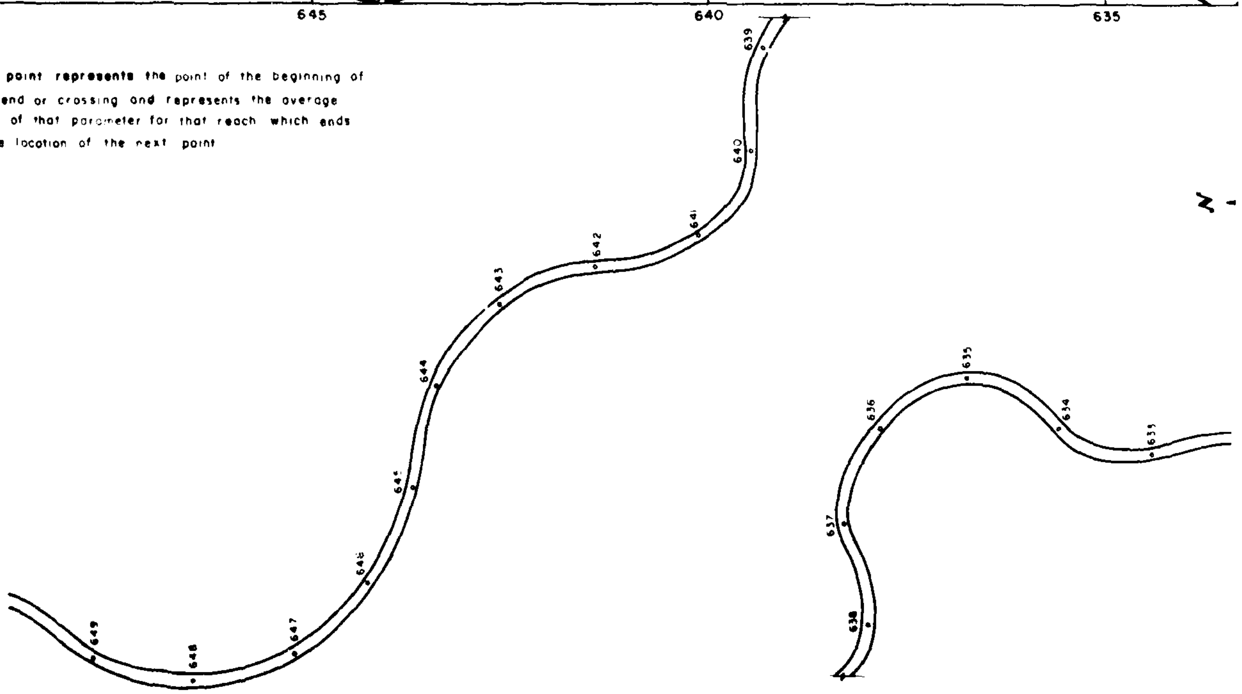


PLATE 2

MISSOURI RIVER HYDRAULIC PARAMETERS
(FROM 1971 HYDROGRAPHIC SURVEY)



Note: Each point represents the point of the beginning of the bend or crossing and represents the average value of that parameter for that reach which ends at the location of the next point



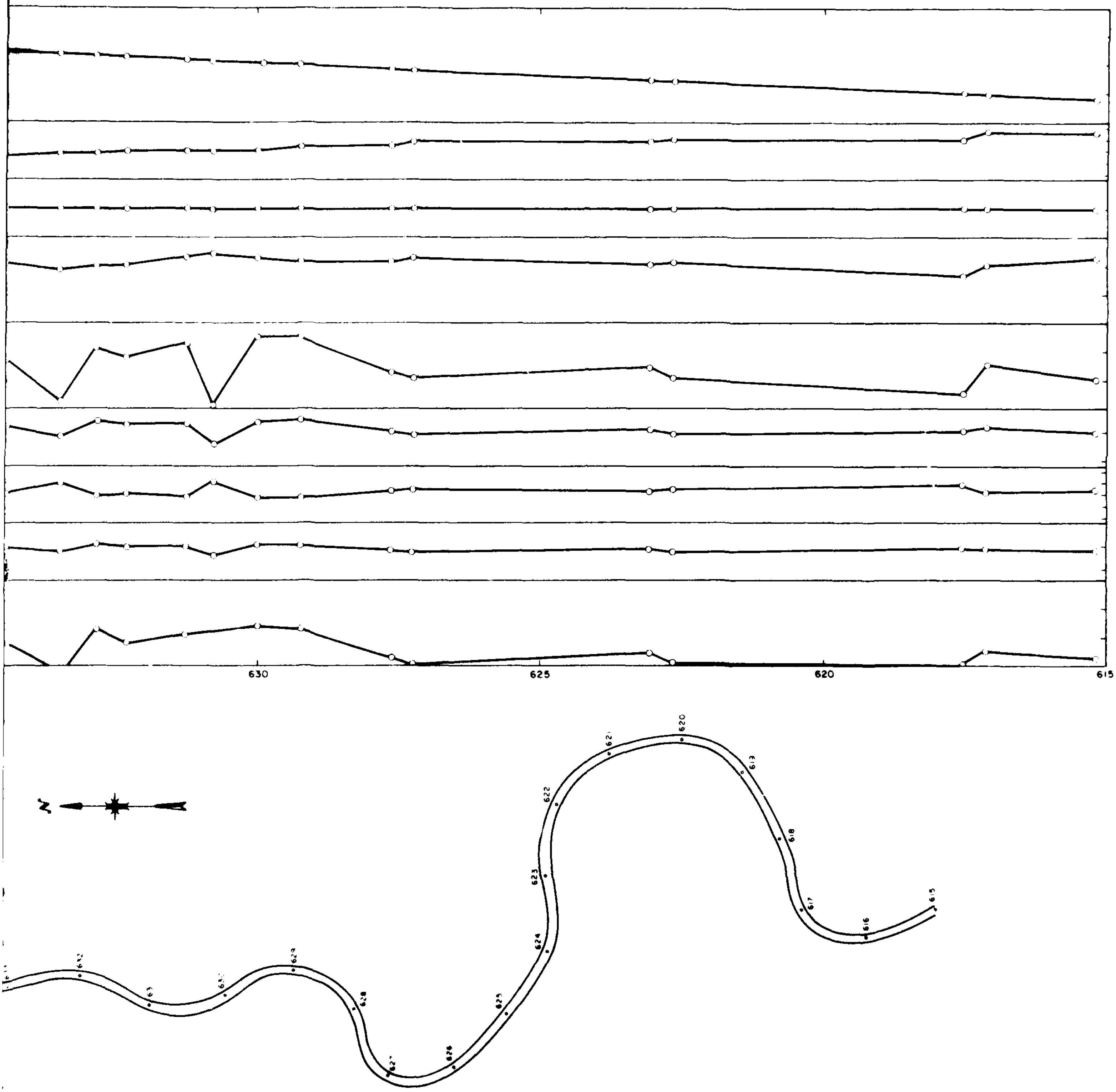
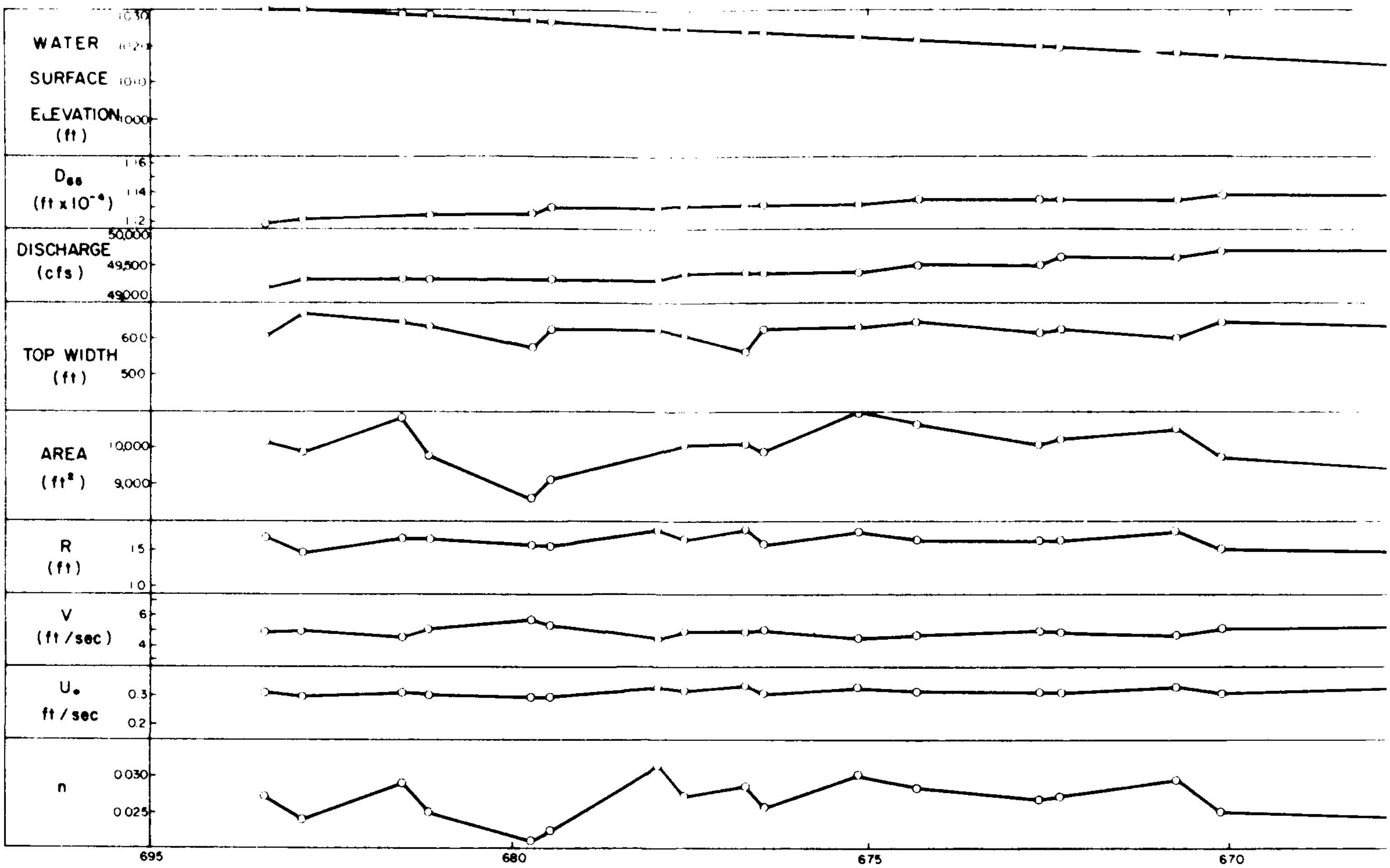
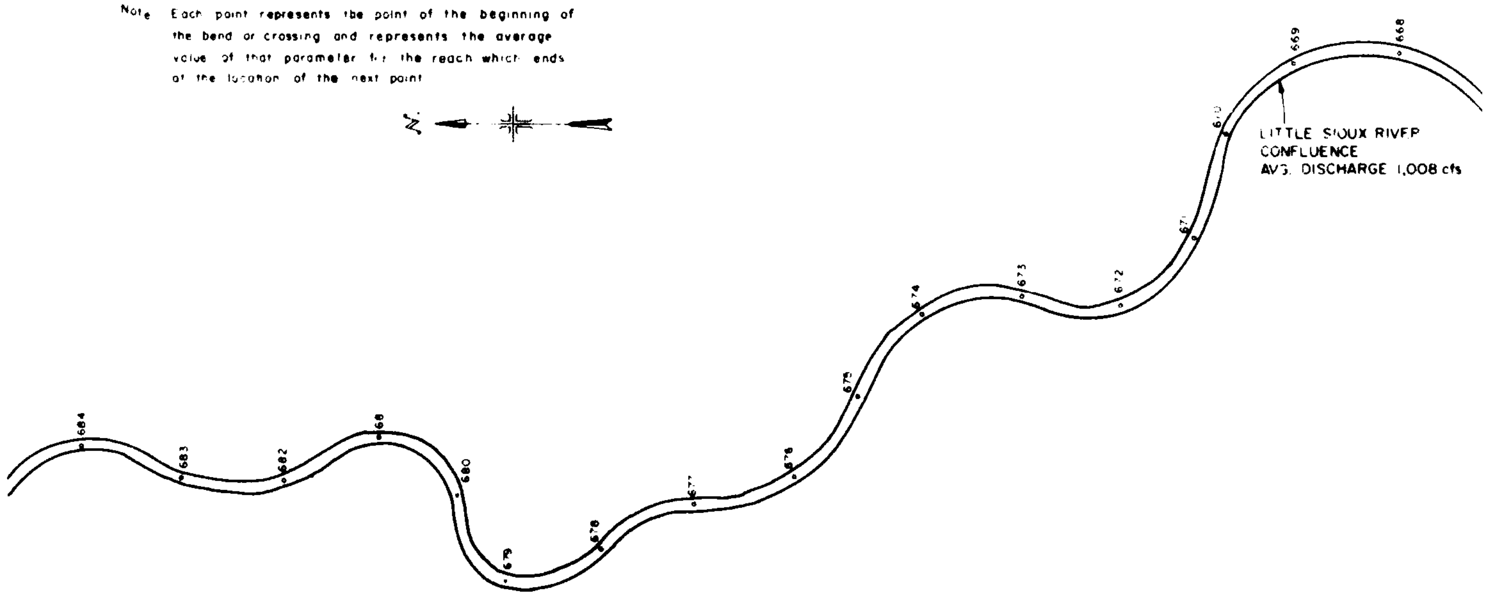


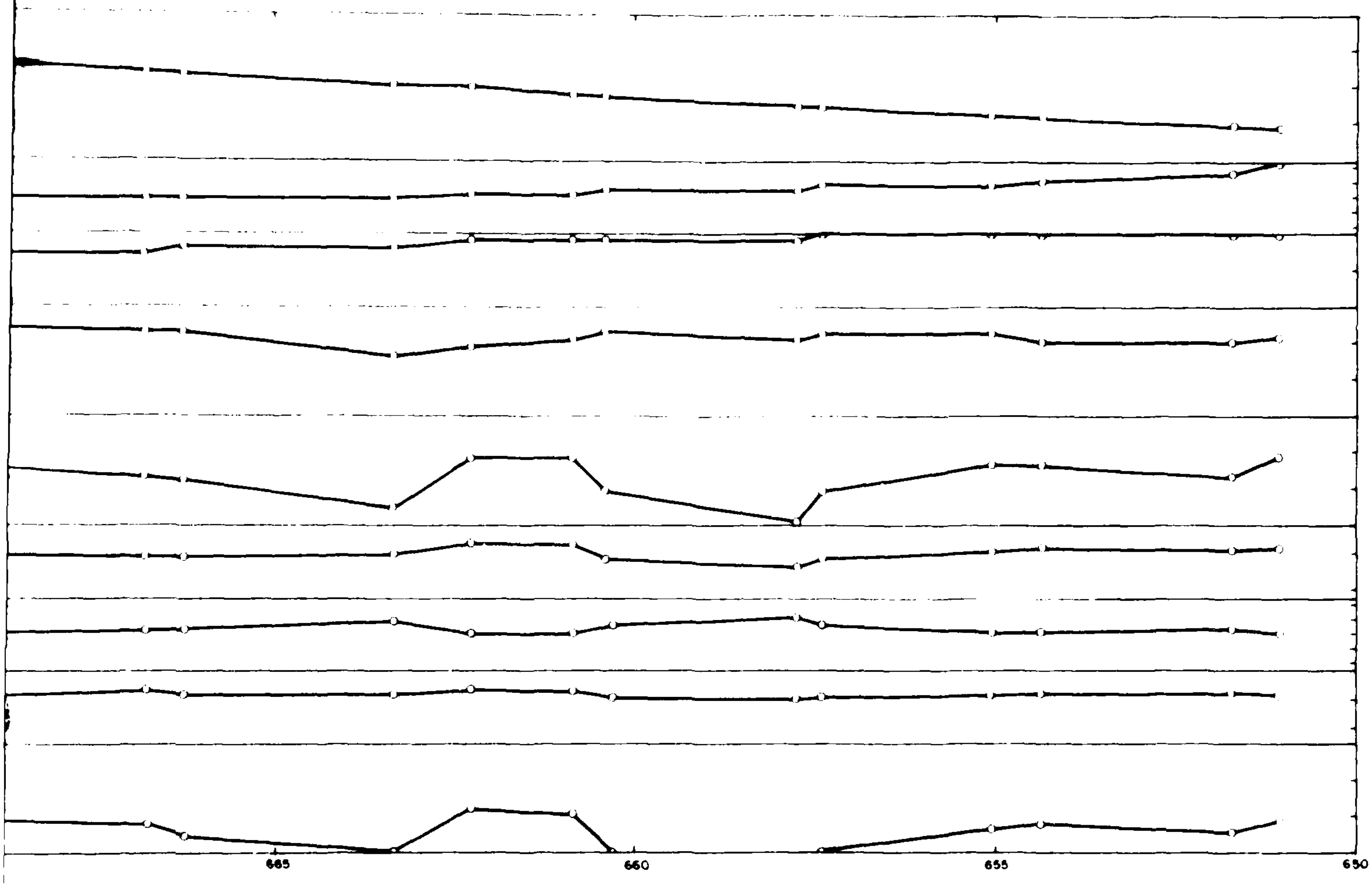
PLATE 3

MISSOURI RIVER HYDRAULIC PARAMETERS
(FROM 1971 HYDROGRAPHIC SURVEY)



Note: Each point represents the point of the beginning of the bend or crossing and represents the average value of that parameter for the reach which ends at the location of the next point





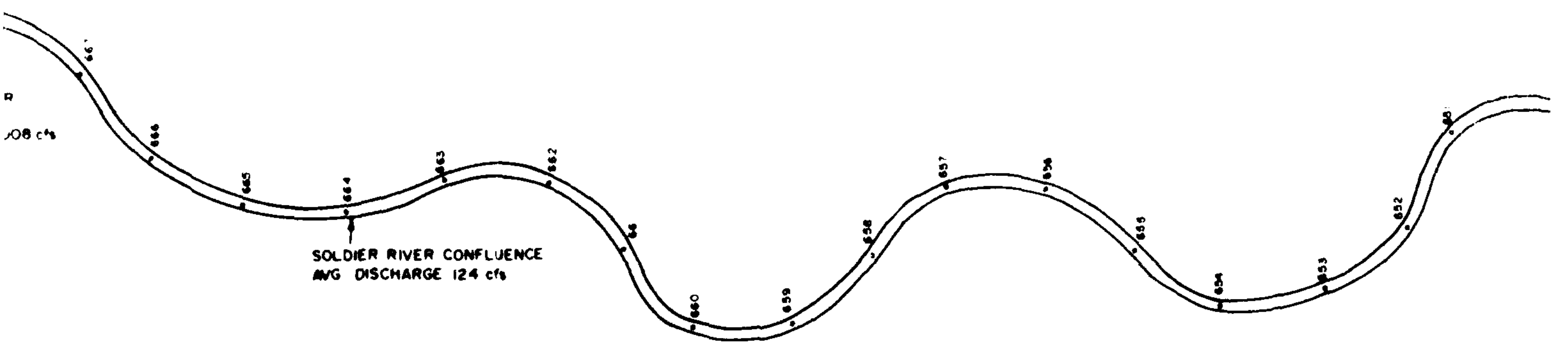
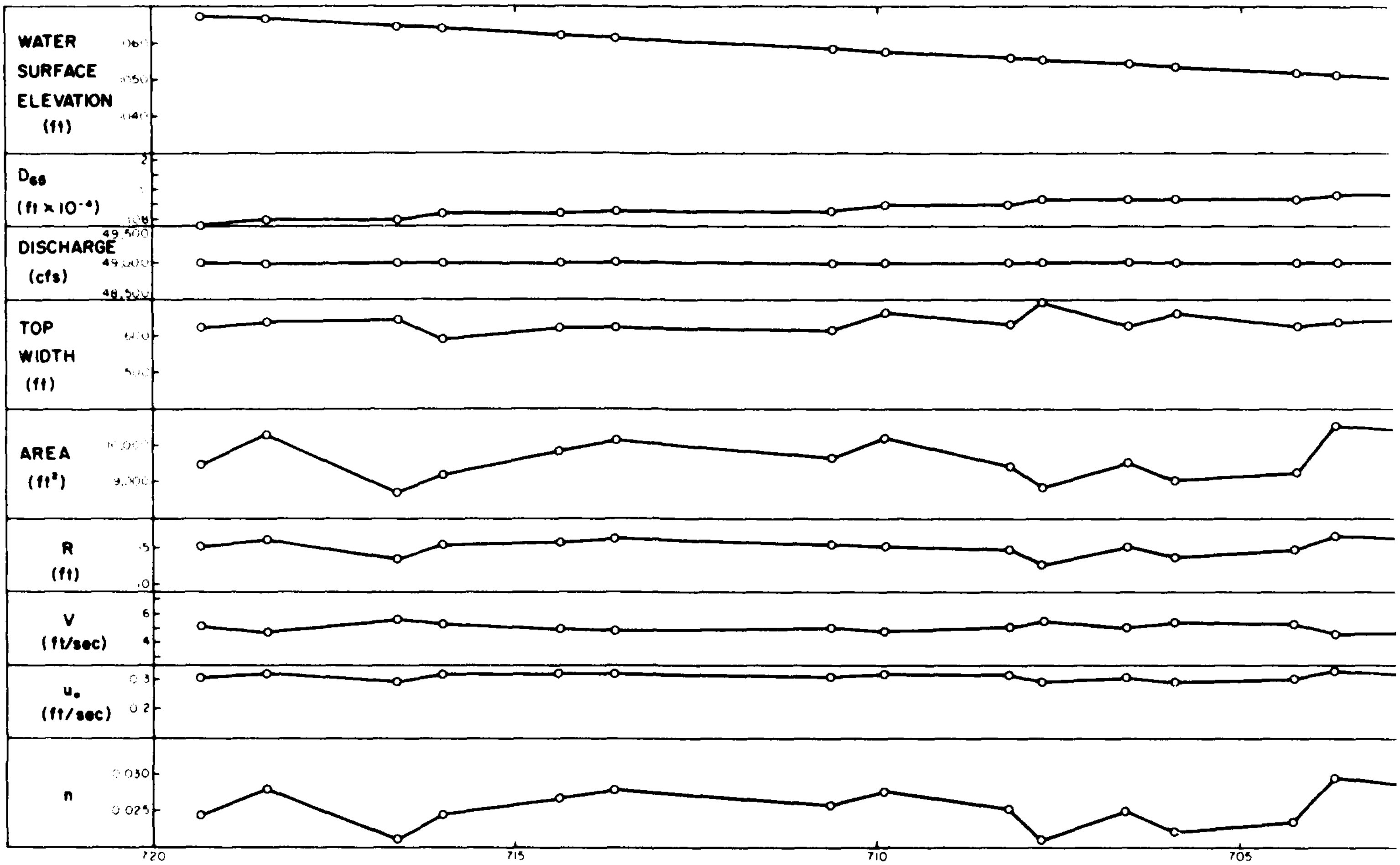
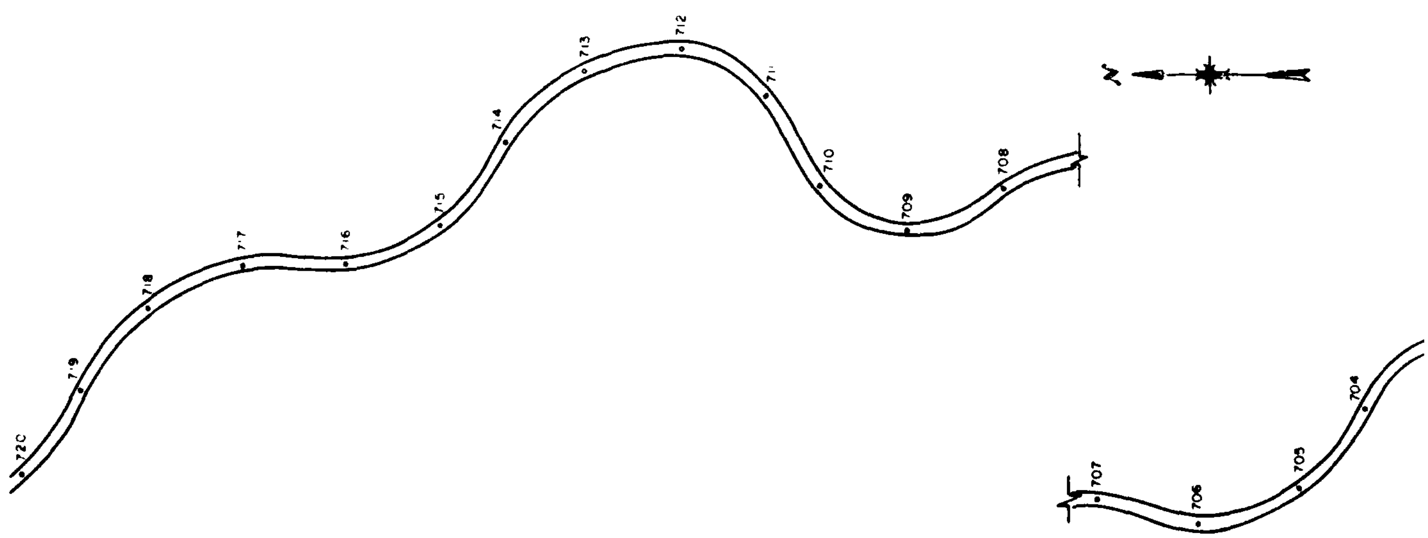


PLATE 4

MISSOURI RIVER HYDRAULIC PARAMETERS (FROM 1971 HYDROGRAPHIC SURVEY)



Note: Each point represents the point of the beginning of the bend or crossing and represents the average value of that parameter for that reach which ends at the location of the next point



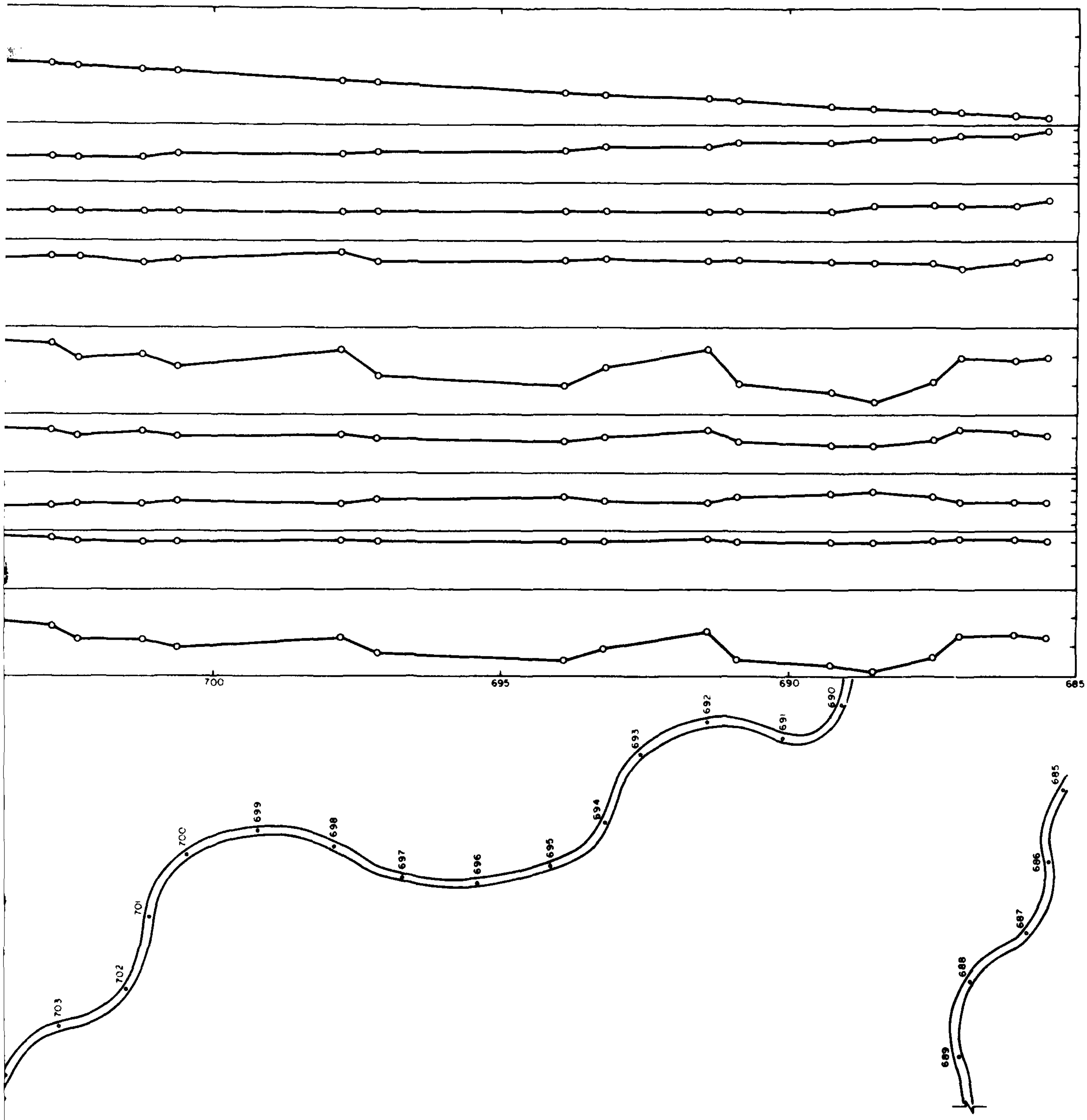
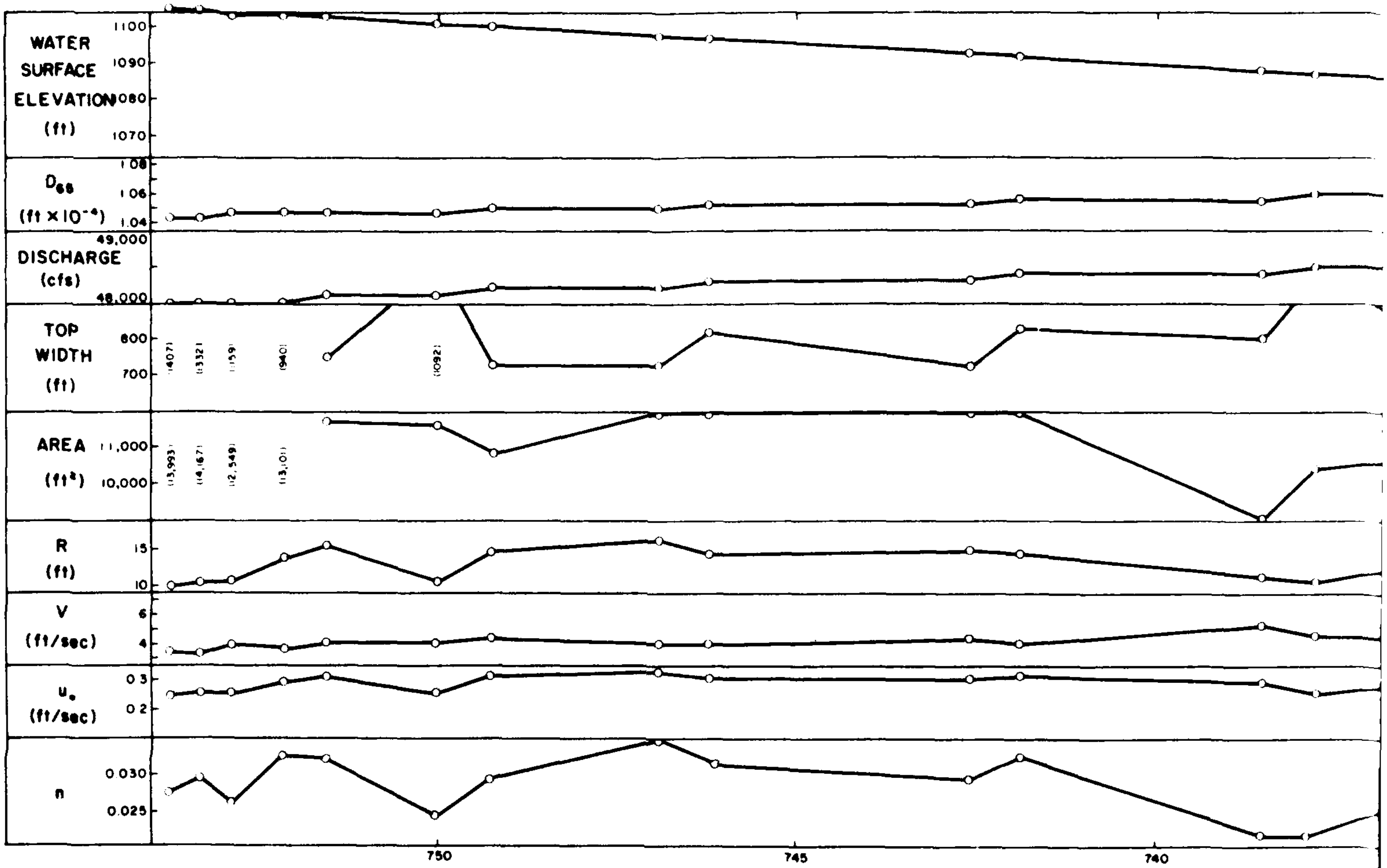


PLATE 5

MISSOURI RIVER HYDRAULIC PARAMETERS (FROM 1971 HYDROGRAPHIC SURVEY)

2



Note: Each point represents the point of the beginning of the bend or crossing and represents the average value of that parameter for that reach which ends at the location of the next point